

T E R R A

MAGAZINE OF THE
NATURAL HISTORY MUSEUM
OF LOS ANGELES COUNTY

VOLUME 31, NUMBER 3
SPRING 1993



BOARD OF TRUSTEES OF THE
NATURAL HISTORY MUSEUM
FOUNDATION

Richard S. Volpert**
Chairman, Board of Trustees
H. Frederick Christie
President, Board of Trustees
Ed N. Harrison**
President, Board of Governors

Robert V. Adams
Robert S. Attiyeh
Bruce Berman
Mrs. Jane Boeckmann**
Franklin Otis Booth, Jr.**
Millicent Hearst Boudjakdji
Neal Brockmeyer
Judge Wm. Matthew Byrne, Jr.*
Richard Call, M.D.**
Edward M. Carson
Otis Chandler
James H. Cheney
David Comsky**
Mrs. Arthur L. Crowe
Mrs. Justin Dart*
Ted R. Estrada**
Matthew K. Fong**
Gary J. Fowler**
Albert B. Glickman*
Alex W. Hart*
Dr. Ray R. Irani
Mrs. Robert G. Irvin**
Edward A. Landry
Mrs. Kenneth Leventhal
William M. Marcussen**
Angus W. McBain
Dan L. McGurk
G. Everett Miller*
William A. Mingst
Stephen R. Onderdonk
George C. Page
Robert E. Petersen
Mrs. Thomas Reddin
Sheldon Richman
Dolores Samuelian**
Richard C. Seaver
Marc A. Seidner**
Marilyn F. Solomon
Mrs. James Stewart*
Dr. Mae Sue Talley*
Frank G. Wells
Barbara White-Thomson
John G. Wigmore**
Dr. M. Norvel Young**
William R. Zimmerman

ALLIANCE BOARD
OF DIRECTORS

Mr. A. F. Osterloh III
President
Mr. Neal H. Brockmeyer
Immediate Past President
Robert S. Attiyeh
Walter S. Berkman
William J. Bird
James Cheney
Judith Cobb
Mrs. Francis L. Dale
J. Shelton Ellis, Jr., Honorary
James C. Eppenbach
Mrs. Robert Feinerman
Patricia Herbert
Andrew J. Hopwood
Diana Jacobs, Honorary
Marshall I. Kass
Mrs. Lindbergh Kawahara
Katherine P. Kline, Honorary
Carole Sumner Krechman
Robert Lane
Mrs. Kenneth Leventhal
Ernest M. Lever
Marvin H. Lewis
Mrs. Hugh H. Logan, Emeritus
Patricia Lombard
Alan G. Lowy
Douglas J. Macdonald
Mrs. Maurice Machris
Ray T. McCullough
Mrs. Alden McKelvey
Stephen R. Onderdonk
Robert T. Patterson
Dave Peterson
Mrs. Dan Pocapalia
Mrs. Thomas Reddin
Mrs. Charles Rinsch
Robert Rivero
Susan W. Robertson
Jack Rodman
Paul Russell
Ethelda Singer
Peggy Sloves
Robert Sloves, M.D.
Mrs. Irving Stone
Robert Swartz
Mrs. Arnold Travis
Harry H. Tytle
Mrs. Robert K. Wrede
Lorraine P. Young

*Trustee Emeritus

**Governor



Satellite images have come to play a significant role in documenting the impact of human activity on Earth. These images simulate a 25-hour view of Earth. See "Global Warming on Trial," page 16. Photo courtesy of Tokai University Research and Information Center, Tokyo.

TERRA

THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
VOLUME 31
NUMBER 3
SPRING
1993

DIRECTOR
Craig C. Black

CHIEF DEPUTY DIRECTOR
Mark A. Rodriguez

LOS ANGELES COUNTY BOARD OF
SUPERVISORS

Gloria Molina, FIRST DISTRICT
Kenneth Hahn, SECOND DISTRICT
Edmund D. Edelman,

THIRD DISTRICT
Deane Dana, FOURTH DISTRICT
Michael D. Antonovich,

FIFTH DISTRICT
HEAD OF PUBLICATIONS
Robin A. Simpson

EDITOR
Ann Seaman

EDITORIAL BOARD
Craig C. Black • Daniel M. Cohen •
Janet R. Fireman • Joan C. Grasty •
John M. Harris • William A. Mingst
• Harry J. Pack • Mark A. Rodriguez
• Ann Seaman • Robin A. Simpson

DESIGN
Dana Levy, Perpetua Press
D.J. Choi

PRODUCTION COORDINATOR
Letitia O'Connor

MUSEUM PHOTOGRAPHERS
Dick Meier • John De Leon

OFFICE MANAGER
Sharmayne Padilla

ADVERTISING SALES
CONSULTANT
Heide Thorstenson, Western Media
Sales



TERRA is published by the Natural History Museum of Los Angeles County and is sent as a benefit to Museum Members. Single copy price: \$4. Subscriptions: \$14 per year. For membership information, visit the Membership Office at the Natural History Museum or call 213/744-3426. All other inquiries may be directed to the Publications Office, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007. Printed by Dai Nippon Printing Company, Hong Kong. Typography by Keyboard Network. All Rights Reserved. Reproduction in whole or in part without permission is prohibited. ISSN 0040-3733. © Natural History Museum Foundation

CONTENTS

3

Museum on the Move

5

The Times Mirror Hall of Native American Cultures

8

Indian Country, L.A.
by Joan Weibel-Orlando

16

Global Warming On Trial
by Wallace S. Broecker

26

Tale of a Ravaged River
by Eric G. Barham

36

Modest Fortunes
by Donald Chaput, William Mason, and David Zárate Loperena

43

Acquisitions
LOST AND FOUND TRADITIONS

45

Southland Diorama
THE ORANGETHROAT PIKEBLENNY

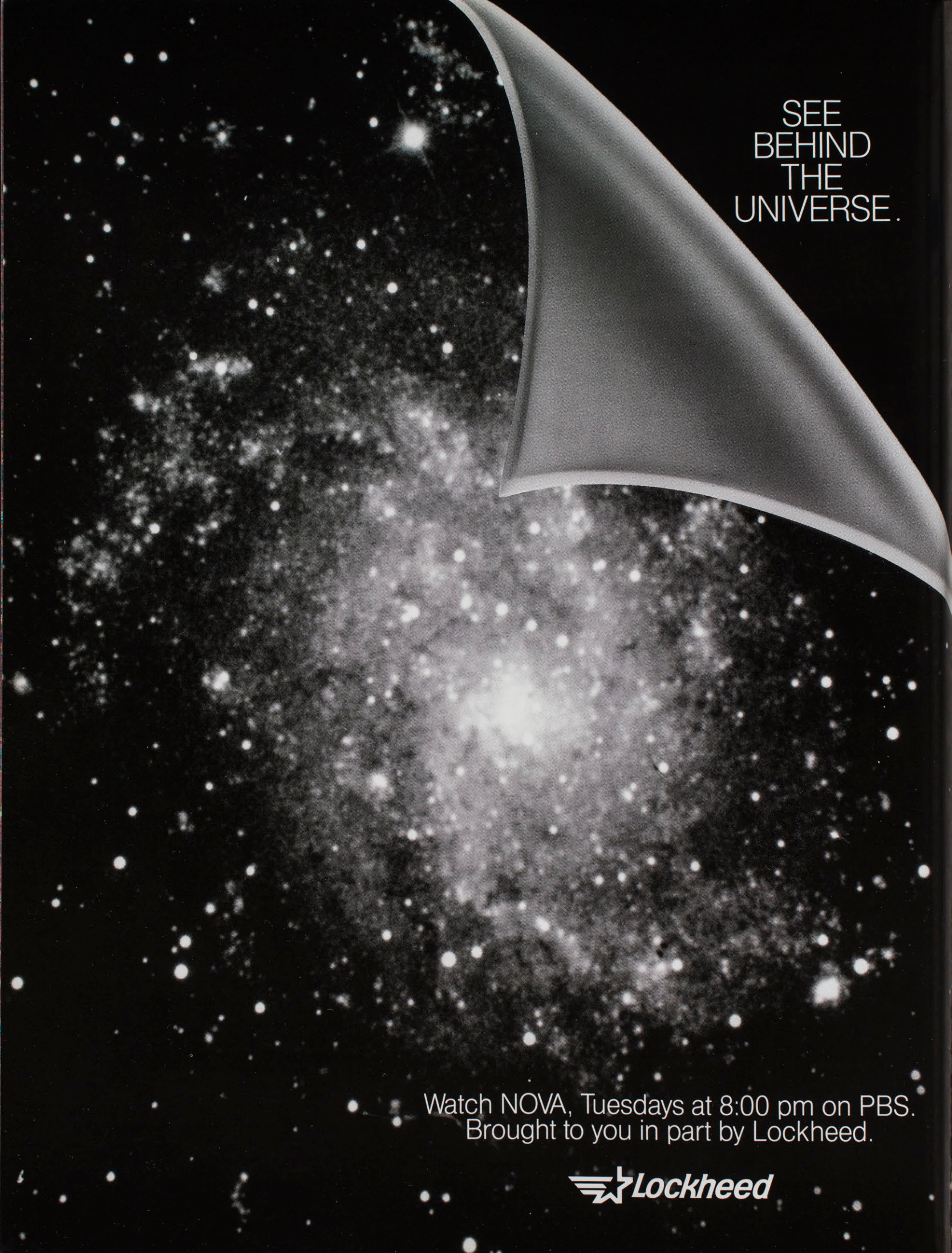
46

Focus on the West
THE SAN LUIS REY MISSION

48

Exposition
PLEISTOCENE SEA SHELLS

< The once-solid canopy of the Brazilian rain forest at Rondônia is fractured with roads cleared by farmers in this 1991 NASA Landsat photograph. Photo provided courtesy of World Perspectives, San Rafael, California.



SEE
BEHIND
THE
UNIVERSE.

Watch NOVA, Tuesdays at 8:00 pm on PBS.
Brought to you in part by Lockheed.



Museum on the Move

STAFF

■ ANTHROPOLOGIST RETURNS FROM PERU

Dr. Karen Wise, Assistant Curator of Anthropology, recently completed three months of archaeological field research on the southern coast of Peru as part of the Ilo Preceramic Project, which she directs. Dr. Wise and her team of collaborators and students from the U.S. and Peru conducted excavations at several sites near the town of Ilo, Peru.

The field work was a continuation of Dr. Wise's study of a 6,000 to 8,000 year old cemetery of the cultural tradition known as Chinchorro. The Chinchorro people lived in small villages on the coast of the south central Andes, practiced a fishing economy, and artificially mummified many of their dead. *Villa del Mar*, the site on which Dr. Wise is working, is the first Chinchorro site documented from Peru.

The 1992 field season of the project was supported by a grant from the Taylor Science Fund of the Natural History Museum's Life Science Division, and by Southern Peru Copper Corporation.

■ DEBATE ON FUNGI SYSTEMATICS SUBJECT OF SYMPOSIUM

Don Reynolds, Curator of Botany at the museum, and **John Taylor** of the University of California, Berkeley, convened a conference on the systematics of fungi at Newport, Oregon in the fall. The colloquium reopened a taxonomic discussion that goes back more than two centuries and concerns the dual classification of fungi that separates those exhibiting structures associated with sexual reproduction from those lacking evidence of sexual reproduction. Asexual evolution is a contemporary issue in fungal classification. The question is important because of its implications for the study of evolution and because it impacts the ways in which museum

collections are classified — in particular those that might lend themselves to new studies using DNA and molecular data.

■ HISTORY OF VISUAL ACCOUNTS OF EXPLORATION RESEARCHED

Dr. Christopher Steiner, Assistant Curator of Anthropology, spent several months of 1992 in libraries and archives in France and the U.S. researching the ways in which "primitive" societies were illustrated by European artists of the sixteenth to nineteenth centuries. Never having visited the faraway places and peoples they were depicting, these artists were forced to rely on their imaginations and on sources such as Bible illustrations and compendia of Greek mythology. The result, repeated by subsequent artists, was a system of symbols and meanings that identified these non-European cultures in European terms. Dr. Steiner amassed a large amount of data that will allow him to trace and interpret the cultural-historic roots of a whole series of such themes and images. His book on the subject will be completed in 1994.

GRANTS

■ NATIONAL GEOGRAPHIC SOCIETY FUNDS INVERTEBRATE ZOOLOGY EXPEDITION

The National Geographic Society has awarded a research grant of \$10,699 to **Dr. Joel W. Martin**, Associate Curator of Invertebrate Zoology, to support an expedition to *Isla del Coco* (Cocos Island), Costa Rica, in early 1994.

Cocos Island is the largest uninhabited island in the world, and the only one in the eastern Pacific classified as a tropical rainforest. The fauna and flora of the island show an interesting mixture of mainland Central American and western Pacific components.

Dr. Martin, whose research centers around the functional morphology, systematics, and diversity

of decapod and branchiopod crustaceans, will be leading an expedition of six scientists, including **Dr. Gordon Hendler**, the museum's Curator of Invertebrate Zoology, and **Hans Kuck**, Collections Manager of Crustacea.

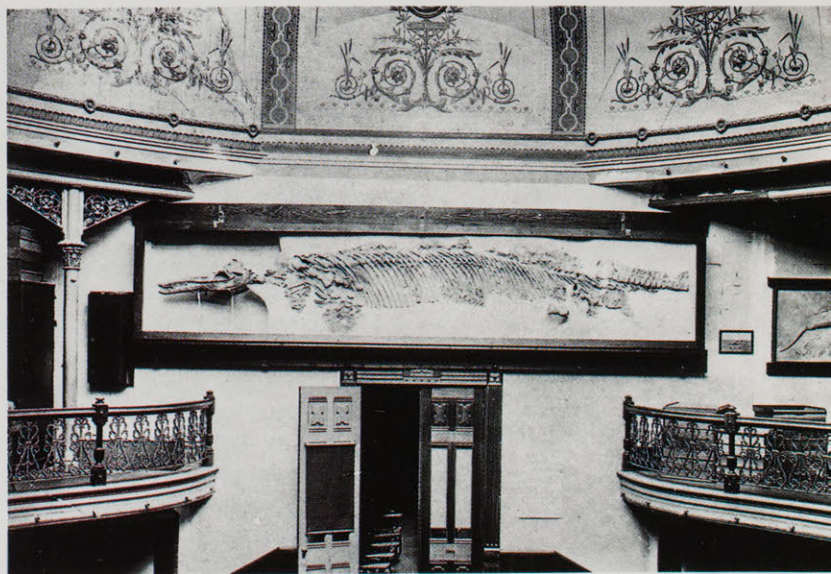
The grant, in combination with a similar grant from the Weiler Foundation, will allow **Dr. Martin** and his team to document and photograph the crabs, shrimps, and lobsters of Cocos Island and to compare the island's fauna with that of other eastern Pacific islands.

■ STOCK FAMILY DONATES PHOTOGRAPHS TO PAGE MUSEUM

The George C. Page Museum's Chester Stock Memorial Library Archive received a donation of 49 historic photographs from **Mrs. Jane Sullivan**, daughter of the museum's former Chief Curator of Science, **Chester Stock**. The images capture **Dr. Stock** at various points during his long paleontological career, from his student days through his position at the Los Angeles County Museum and the California Institute of Technology. Most of the prints contain notations on their backs in **Stock's** own hand, identifying the date and location of the photographs.

This rare photo of the interior of Bacon Hall at the University of California, Berkeley, was taken around 1915. Constructed in 1881 as a library and razed in 1961, Bacon Hall was one of the most architecturally significant structures on the Berkeley campus. When a new library was built in 1910, the departments of Geology, Mineralogy, Paleontology, and Physics moved into Bacon Hall.

The picture, which shows an ichthyosaur specimen on the wall, is one of 49 historic photographs donated to the George C. Page Museum's Chester Stock Memorial Library Archive by **Mrs. Jane Sullivan**, daughter of the museum's former Chief Curator of Science, **Chester Stock**. Professor **Stock** came from Berkeley to the California Institute of Technology in 1925 and was hired by the Natural History Museum (then the Los Angeles County Museum of History, Science and Art) in 1931. His classic studies of the fossil mammals of Rancho La Brea continue to be a primary research source for paleontologists around the world.



■ FRIENDS OF HART SUPPORT PROGRAMS

The Friends of Hart Park and Museum, a support group of Santa Clarita citizens, underwrote the entire supplies and services budget for the Hart Museum for the 1992-1993 fiscal year. The funding furnished materials for tours and outreach programs as well as volunteer training and office supplies. The Friends of Hart also provided for cleaning the museum's entire collection of 56 oil paintings of Western art, which includes original works by Charles Russell, Joe De Yong, James Montgomery Flagg, and other artists who were friends of actor and philanthropist William S. Hart. Fundraising is currently underway for the painting and re-roofing of the house.

DEVELOPMENT

■ FELLOWS

With Ray McCullough as the new Chair, the Fellows began the fiscal year with a plan to enhance membership in the program through a lively calendar that includes family events among its opportunities. In October, the Fellows rediscovered the museum, inviting friends and colleagues to a fascinating behind-the-scenes tour. Curators were on hand to answer queries that came from the wide-ranging interests of the participants. Also in October, Fellows families enjoyed a day of Halloween fun that included pumpkin carving, face-painting, caricatures, and balloon animals. In November, the Fellows had the uncommon opportunity to meet Robert Bateman, renowned wildlife artist whose paintings were on display in the Director's Gallery. In January, Fellows' children came to the museum to enjoy the animated exhibit Dinosaurs and Ice Age Mammals. The adults were treated to a backstage tour of Warner Brothers Studio with Trustee Bruce Berman, followed by dinner and a private screening.

■ CORPORATE AND FOUNDATION SUPPORT

Camilla Chandler Frost, Allied-Signal Aerospace Company, Mr. and Mrs. W. Owens Millér, Iona Benson, and the Shea Foundation have provided generous support for the museum's environmental education programs during 1992, including docent tours, teacher workshops, the Discovery Center, the Research Apprentice Program, and other key environmental programs. A significant gift from the Sidney Stern Memorial Trust strengthened the museum's Research Apprentice Program, which enables 30 talented high school students to study science for a full year with museum curators and educators. Additional support for this unique program was provided by Richard Griot and Bob Swartz and Grace Labatt.

Generous gifts from the Norris and AMGEN Foundations funded the Classroom Collection program. National Medical Enterprises continued its support for the Senior and Special Education Outreach programs, and a grant from the Albertson Foundation will support the museum's core education programs.

The museum welcomes the Aluminum Company of America as a new member of the Business Associates program. As part of a continu-

ing series of events designed to involve the business community in the museum's programs, former governor George Deukmejian addressed a group of business executives at a luncheon in September of 1992. Governor Deukmejian spoke about ways to improve the business climate in California, and guests heard presentations on the museum's diverse education programs for children and adults.

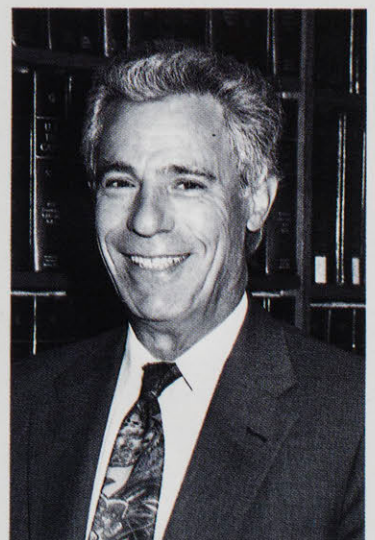
■ PLANNED GIVING COMMITTEE ANNOUNCES

CHAIRS William G. Bird and Marvin H. Lewis have accepted the co-chairmanship of the newly formed Natural History Museum Foundation Planned Giving Committee, which is designed to inform the museum's constituency of the many advantages of estate planning that includes the museum. Mr. Bird, a graduate of Stanford Law School, is a partner in the firm of Musick, Peeler and Garrett. Mr. Lewis, who received his law degree from the University of San Francisco, heads the Estate Planning, Trust and Probate department at the firm of Ervin, Cohen and Jessup, where he is a senior partner.

Both men have been active participants in the museum for many years and currently serve on an executive committee of the museum Foundation's Alliance Board.



William G. Bird



Marvin H. Lewis

The Times Mirror Hall of Native American Cultures

THE NATURAL HISTORY MUSEUM of Los Angeles County is proud to announce the opening of its Times Mirror Hall of Native American Cultures. The 10,000-square-foot permanent exhibition makes use of more than 800 objects from the museum's permanent collections to explore such themes as the environmental basis of traditional Indian lifeways, men's and women's contributions to Plains society, and the historical development of Native American arts. In all, the new hall provides a broad and multifaceted interpretation of Native American history and contemporary life.

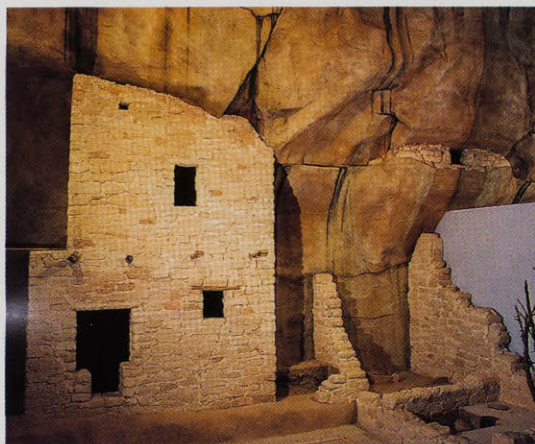
The new exhibition deals with American Indian cultural traditions from the prehistoric past to the present day, but it focuses in particular on the last two centuries, during which Native Americans have faced difficult and constantly changing circumstances. In a departure from the ways in which museums have told the Native American story in the past, artifacts in the Times Mirror Hall are placed in historical as well as cultural context, so that changes over time — in design and styles of tools, containers, and clothing, for example — are tied to the effects of historical events on the peoples that created the objects. The interaction between Europeans and indigenous North Americans is shown through the resulting changes in American Indian lifeways.

The new hall is unusual in its perspective: rather than presenting tribal cultures in isolated vignettes, frozen at some point in time, the hall depicts regional and cultural customs in dynamic juxtaposition that reflects actual historical conditions. The exhibition opens with the history of the indigenous peoples of southern California and then proceeds to examine some of the traditions that are the heritage of the heterogeneous group of Native Americans assembled in Los Angeles today. This rich picture of diversity has as its counterpoint a second main theme of the exhibition — the development of Native American arts, considered on the whole, from prehistoric times to the present. The two themes are explored through recreations of environments such as a Pomo riverbank, where sedge for basket making is being harvested; a traditional Zuni waffle garden, showing an effective use of water in an arid land; and the "collector's corner" in an early twentieth century Craftsman bungalow, where museum visitors are led to consider the influence of non-Indians in defining Native American artistic trends as well as the composition of museum collections.

One area of the hall is dominated by a two story high prehistoric Pueblo dwelling based on those at Mesa Verde in Colorado; the massive re-

construction is presented to introduce the idea of architectural continuity, which pervades the Pueblo tradition. Such elaborate full-scale architectural and environmental dioramas, and the objects displayed throughout the hall, provide a dramatic and compelling context in which to explore people's lives and historical experiences.

Whenever possible, objects exhibited are identified with individual artists and historically important figures. Historic as well as modern photographs of people are used, and the voices of Native Americans are heard in the hall: residents of Los Angeles talk about their recent history and their lives in the city today in a film presentation, and the exhibition draws upon the rich tradition of American Indian oral history, literature, and autobiography in explaining events and circumstances. The result is an environment with a personal and emotional dimension as well as a factual tenor.



The Times Mirror Hall of Native American Cultures contains a life-sized reconstruction of a cliff dwelling of the Pueblo III period, 1100-1300 A.D.

Perhaps the most profound effect of the new hall is its challenge to our notions of the nature of tradition. Conventional wisdom holds that small ethnic communities that find themselves surrounded by a larger and different society must retain their traditions unchanged to avoid loss of cultural integrity. But the new hall shows the adaptive nature of tradition, the surprising ways in which cultures maintain their continuity, and the role of the outsider in the process of delineating cultures and communities. The exhibition presents traditions as continuing, not ended; as open to influence rather than pristine; and as clearly influencing and contributing to other traditions rather than remaining isolated and ingrown.

Dr. Margaret Ann Hardin, Curator of Anthropology, provided the concept and narrative for the Times Mirror Hall of Native American Cultures and guided the massive undertaking from initiation to completion. Exhibit designer Jean-Jacques Andre devised an engaging series of three-dimensional environments to bring the hall's narra-

Wolf Dance Shoshone 1900, painting on muslin by Charles Washakie; 35 by 42 inches (90 by 107 centimeters), circa 1900. The artist shows a Wolf Dance performed at a Fourth of July festival on a Plains Indian Reservation. The painting is displayed in a portion of the Times Mirror Hall of Native American Cultures that chronicles — from men's and women's perspectives — the transition from the mobile life on the Plains to the reservation era.

tive to life. The daunting task of fabricating and installing the two-story exhibition was carried out jointly by Pacific Promotions, Inc., and the museum's Exhibitions Division, under the direction of James D. Olson.

In its planning stages, the project benefited greatly from the formal and informal participation of Native American individuals and organizations. Native Americans were prominent among the anthropologists and museum professionals who acted as consultants for the hall. Community leaders formed a small oversight committee to guide the production of the film on the Los Angeles Native American community. A number of American Indian artists created pieces for the hall, and the Pueblo of Zuni, through its museum and senior citizens' program, played an active role in shaping the detail of the hall's Zuni exhibits. The hall has steadily unfolded over the past six years in a

manner that reflects one of Dr. Hardin's great strengths — the ability to merge the interests of the Native American community with those of her discipline, and to foster an enduring dialogue between the two points of view.

Major funding for the hall has been provided by the Times Mirror Foundation. Significant gifts were also received from the Wallis Foundation, Chandis Securities Company, the Mildred E. and Harvey Mudd Foundation, Mrs. Justin Dart, U.S. Borax and Chemical Corporation, and First Interstate Bank. Other generous donations were made by Mr. and Mrs. Robert S. Attiyeh, the ARCO Foundation, Diana and David Jacobs, and Occidental Petroleum.

Additional support for the new hall came from an implementation grant from the National Endowment for the Humanities and from a challenge grant from the Kresge Foundation. Many of



the objects on display have been purchased with funds made available through an endowment created by the William Randolph Hearst Foundation.

An unusual feature of the Times Mirror Hall is a changing gallery of contemporary arts, which will keep visitors abreast of artistic developments within the Native American community. Its opening exhibition will focus on neotraditional arts and will include a selection of works from the 400-piece collection that was the basis for the exhibition *Lost and Found Traditions: Native American Art 1965-1985*. The *Lost and Found Traditions* collection was awarded to the Natural History Museum in a competition that included over twenty other museums; it is a gift of the American Federation of the Arts, made possible by the generous support of the American Can Corporation (now Primerica).

The museum's Education Division has begun to incorporate the themes of the new hall in its programming. Public lectures and tours are being offered, as are evening tours for educators, field trips, and outreach programs to schools, special education facilities, nursing homes, and children's and convalescent hospitals. The museum's Earthmobile, a mobile science museum for elementary children in the Los Angeles Unified School District, draws on the content of the Native American Hall as it encourages students to examine the past, present, and future impact of humans in the natural world. The construction of the Earthmobile, which was made possible in 1991 through a generous grant from the Maxwell H. Gluck Foundation, enabled the museum to begin educational programming in archaeology in advance of the opening of the new hall.

We expect that over 1.5 million people, including 500,000 school children in organized classroom tours or with their families, will visit the hall each year. Many of our visitors will be Native Americans, for Los Angeles has the largest concentration of American Indians of any urban center in the United States. I am gratified that the museum is able to provide an innovative exhibition that so emphatically expresses the vitality of Native American cultures. I applaud all who participated in this outstanding enterprise, and I invite everyone to become immersed in the story of North America's original peoples through this exciting and thought-provoking new hall.

CRAIG C. BLACK
Director

Leadership Committee for the Times Mirror Hall of Native American Cultures

Mr. William A. Mingst, Chairman
Mr. Otis Chandler, Vice Chairman
Mr. Robert S. Attiyeh
Richard Call, M.D.
Mrs. Justin Dart
Mr. Ed N. Harrison
Mrs. James Stewart

Major Donors to the Times Mirror Hall of Native American Cultures

Founder

Times Mirror Foundation

Founding Patrons

Wallis Foundation
Chandis Securities Company

Distinguished Supporters

Mildred E. and Harvey Mudd Foundation
Mrs. Justin Dart
U.S. Borax and Chemical Corporation
First Interstate Bank
ARCO Foundation
Mr. and Mrs. Robert S. Attiyeh
Diana and David Jacobs
Occidental Petroleum

The Times Mirror Hall of Native American Cultures received an implementation grant from the National Endowment for the Humanities.

Consultants to the Times Mirror Hall of Native American Cultures

JoAllyn Archambault
Margaret Archuleta
Lowell J. Bean
George Blake
Harry Fonseca
Catherine S. Fowler
Lynn Gamble
Nelson H. H. Graburn
Travis Hudson
Chester King
Randi Korn
Edmund J. Ladd
Kenneth Lincoln
Mabel McKay
Sally McLendon
Judith K. Polanich
Katherine S. Saubel
Joan Weibel-Orlando

Native American Community Advisory Committee for the film

That Our Voices Be Heard

Marvin Abrams
Michael Burgess
Randy Edmonds
Eva Northrup
Steven Stallings

Indian Country, L.A.

by Joan Weibel-Orlando

OPPOSITE

Kelly (Lakota) and Suzie (Pomo) Looking Horse and their three daughters, Weyaka-win, Mauni-win, and Wichagpi-win, pose in front of the Los Angeles City Hall in their Northern Plains dance regalia.

It is another hot, dry, brilliant September Sunday in Los Angeles. The sky is cloudless. It has not rained in months. Only daily irrigation sustains trees large enough to provide a dappled shade for the walkways and buildings of the West Hollywood Recreation Center.

By noon the grounds are already crowded with Westsiders. Knots of young parents busy themselves with barbecue grills, and children scramble down slides and onto the jungle gym. People laze in the sun, read the Sunday Times, and toss Frisbees.

Across the park, a figure strides with moccasined purposefulness, a circle of brilliantly colored feathers at his waist. Oblivious to stares, he walks as if his beaded warrior regalia were customary and appropriate to the occasion. What can be made of this Indian in our urban midst?

Powwows used to be outdoor affairs and went on for three days. In the city, most are held indoors at school gyms and auditoriums.

In the 1950s and 1960s, powwow people tended not to be highly involved in the Indian Christian church organizations, and church people tended not to go to powwows. This was particularly true of emigrants from the Choctaw, Cherokee, Creek, Chickasaw, and Seminole territories in eastern Oklahoma, whose enculturation into Christianity during childhood inculcated a belief that activities such as powwow were pagan, a state akin to consorting with the devil. This social separation has been changing, however. It is now less distinct than it once was — perhaps another effect of urbanization on Indian lifestyle and practices.



THE AMERICAN INDIAN OCCUPIES a singular place in the popular imagination of the world,

beginning with the fascination Native Americans held for Europeans from the first encounters of old and new world cultures. The image of the Indian has surfaced in films and literature in numerous incarnations, from barbarian to noble savage to wily hunter and son of the earth to gritty 20th-century survivor. Mingling with outsized heroic images are more troubling and reductive ones: enslavement, broken treaties, disenfranchisement, isolation, alcoholism, demoralization.

Among these fictional, half-true, and factual portrayals live real American Indians. Decimated in number, restricted for generations to reservation life, they have retrenched, increased their numbers with each decade, and absorbed some of the ways of the dominant culture while retaining valued tribal folkways. Starting in the 1920s and gathering strength from their traditions, they began their ambivalent move to the city.

The 1990 census shows that decidedly more American Indians in the United States live in cities than in rural and reservation areas. No longer residents of isolated, culturally conservative, ethnically homogeneous rural communities, Indians have been migrating to urban centers in significant numbers for at least four decades. Some Indian families have children and grandchildren who were born in cities. For the most part, these second- and third-generation urbanites return only infrequently to their ancestral homes. When they do, it is usually for short holiday visits, school vacations, or a family crisis.

What is the meaning, to individual Indians and to the development of their sense of community and pantribal identity, of time spent in an urban setting? How do mainstream education, gainful employment, and contact with other urban American Indians affect their understanding of who they are as individuals and society members?

Since I began asking these questions in 1973, over 300 Indians who lived for periods of time in Los Angeles have shared their life histories with me. Through these personal narratives I came to understand the properties that define and sustain North America's largest urban Indian community — Los Angeles. And over the 20 years of my work, I have found tangible evidence of continuing community process among the urban Indians of L.A.

North American Indians are among the more recently arrived cultural groups to establish themselves as a community in ethnically heterogeneous Los Angeles. Prior to World War II, there were no more than 5,000 Indians in Los Angeles County; by 1980 that number had increased ten-



fold. While the increase was dramatic, the Indians in Los Angeles represented only a tiny fraction (0.006 percent) of the total county population at that time. In 1990 American Indians were still numerically insignificant when compared to the other major ethnic and racial groups that make up Los Angeles's cultural mosaic. Even the more recently arrived Koreans were present in greater numbers in 1990. Still, the 50,000 Indians of Los Angeles constitute the largest urban Indian population in the U.S.

This is a great irony, considering that until 1770 the Los Angeles basin was populated solely by Native Americans — about 133,000 strong. The most prominent society among them was that of the Gabrielinos, a seminomadic, village-dwelling people who traded with faraway tribes from the country's interior. Trade routes stretched from the southern California coast to as far east as Arizona, New Mexico, and Colorado. The coastal Indians and members of the Great Basin and Southwestern culture complexes regularly traded such goods as decorative marine shells, nuts, maize, turquoise, obsidian, pottery, and textiles. Documented trade routes suggest that these exchanges continued unbroken for at least a thousand years before European incursions into the area.

When Spanish missionaries arrived in the Los Angeles basin in 1769, the devastating pro-

cesses of colonization began. Within 140 years, 90 percent of southern California's native population was gone. Whole societies had been annihilated, their languages and lifeways lost to the world. Only 15,000 Indians were counted in the 1910 census in all of California.

In the 1950s, the Bureau of Indian Affairs began an urban relocation program designed to relieve the pressure on limited reservation resources. The program brought numbers of Indians — most of them totally unprepared for city life — to Los Angeles. Alice Begay, a Navajo, remembered:

When I got [to L.A.] I had to find the B.I.A. [Bureau of Indian Affairs office] downtown. . . . It was real scary because, the tall buildings, it was like being in a canyon. I had the directions on a piece of paper.

I got off there and stood there. It was early in the morning, seven o'clock. The [office] doesn't open 'til nine o'clock. So I stood there with my suitcase and everything for two hours.

. . . It was on the third floor. I [sat] there for the whole day. Finally, they got to me before five o'clock. And they says, "We'll take your application tomorrow. . . . I'm going to take you to this house where all the Indians stay and you're going to have to pay twenty dollars a week. . . ." And I told her, "I don't have any money. I don't have a dime to my name except five dollars that I've been carrying for a long time, I earned baby-sitting at Intermountain Boarding School, but that's all I have." She said, "Okay, I'll give you twenty dollars for tonight."

LEFT

Tribal dance regalia varies widely at urban powwows. This Iroquois man wears a fur hat and beaded apron which, in design and material, are consistent with his Northern Woodlands aesthetic and ritual traditions.

RIGHT

Swirling color, insistent drum beats, an intensity of movement and purpose — this award-winning "fancy dancer" is lost to the spirit of the dance, and finds himself within it.

OPPOSITE

The flamboyant colors of this young man's double bustle outfit mark him as a "fancy dancer." The original powwow dance regalia was more subdued in tone. The use of such vibrant colors for dance outfits occurred with the introduction of aniline dyes at the end of the 19th century.



Many relocated Indians, lacking marketable work skills and not having been fully inculcated with the dominant culture's work ethic and ethos, became discouraged. Many made frequent, extended trips back home, or simply returned there for good. Even federally-funded employment programs and vocational training did not help. By the mid-1970s, their own statistics told B.I.A. officials that their urban relocation strategy had not met its goals. The program was terminated in 1980.

But some Indians continued to migrate to Los Angeles. My 1977 study showed that only half of the Indians in the city at that time had come via any federal relocation assistance program — the rest had come on their own. By 1980, slightly fewer than 200,000 American Indians, Eskimos, and Aleuts lived in California, with 80 percent of them living in cities. If urbanization of the American Indian was a federal policy goal, in California, at least, that outcome indeed had been reached in a relatively short period of time — much of it with little or no federal expenditure.

Today, the Los Angeles Indian community is characterized by extreme cultural heterogeneity, including indigenous Californian groups, for even though migration to the city is a significant phenomenon, there are numerous lineages that have been here all along, and they have provided the foundation both for the assimilation of successive groups and for the synergy that has made that assimilation possible. Other features of the Los Angeles Indian community include a dispersed settlement pattern and scattered locations of symbolic and instrumental action — all factors that usually mean a fragile or nonexistent social cohesion. However, during my 20 years of association with American Indians in Los Angeles, I have found a viability, tenacity, and political power far beyond that suggested by their loose social organization and small numbers. It forced me to reexamine my ideas about what constitutes community and about how community is developed and maintained in complex society.

The mechanisms that foster a sense of belonging and a shared identity among Los Angeles Indians — who belong to an extremely varied collection of tribal groups — do not rest solely on rigid economic and institutional bases. What substantial numbers of Los Angeles Indians think of as their community is something that resides in the mind, or reflects a sentiment, and it is not restricted by distance, nor dependent on the sharing of space.

Certain activities provide a continuing sense of history, community, and ethnic identity. The modern-sounding L.A. City-County Native American Indian Commission, for example, springs from the politically motivated tribal coun-



The yarn fringes of this Cheyenne/Arapaho man's dance regalia mark him as a "grass dancer."



cils of the 19th century. But the most visible and durable enterprise providing continuity has to be the powwow, which has its roots in tribal rituals that predate European contact.

The term "powwow" is a variant of the Algonquian word *pawaw* — a large communal ceremony led by a healer or shaman for spiritual, war, or healing purposes. Later, the meaning was expanded to include any type of council or intertribal conclave. However, powwows as practiced today throughout North America are descended from a custom that first arose among the Plains Indians and included several days of ceremonial dancing, preparation for the hunt, trading, and social interaction.

The contemporary powwow is thought to have its origins in the social dances held each summer during the Plains Indians' tribal congresses and just before their great communal buffalo hunts of midsummer. While men hunted, women butchered, dressed the skins, and prepared the meat for the long winter ahead. With the setting of the sun, the entire camp of different (although linguistically and culturally related) family bands gathered in the open, grassy areas. Camp fires were lit, and men and women donned their finest ceremonial regalia. To the sounds of buffalo hide drums, gourd rattles, shrill bone whistles, and reed flutes, the people proclaimed the cultural unity of their different family groups in dance and song, sometimes into the next day. The rituals were to propitiate the spirits of the buffalo, to honor ancestors and departed warriors, and to invoke prayers of assistance or initiation, as well as to socialize, gossip, arrange marriages, right previous wrongs, and heal.

As Plains Indians began to migrate to urban centers, they incorporated elements of the summer powwow into their new urban lifestyles. And as befits any adaptive process, the powwow gradually came to reflect the proscriptions of the new milieu. Instead of being held in the traditional months of June through October, they were moved to September through June so as not to conflict with the traditional summer powwow season. They became more secular in tone, although there have been decided attempts to reintroduce sacred elements into urban powwows in the last decade. No longer an expression of tribal unity, they became increasingly intertribal and panethnic. They are now public events that anyone, Indian and non-Indian, may attend.

But the most telling of the tribal powwow's many evolutionary adaptations is the fact that it has become, in the city, a pantribal marketplace. Increasingly, commercial elements have been introduced into traditional powwow activities. Today large portions of the activity area are designated as "traders' areas" with booths displaying jewelry,



Powwow dance regalia undergoes continual stylistic shifts. These young girls sport their prized "jingle" dresses. Once on the decline because of the prohibitive cost of the silver or steel decorations, this dance dress style is regaining popularity as people now fashion the "pop tops" of soda and beer cans into decorative (if less mellifluous) "jingles."

Women learn and perform "fancy dance" steps, once only the province of male dancers.

From American Indian to Indian-American: the Urban Experience

"MANY TIMES IN THE past, we Indians were faced with conflicts from within our ranks and from outside forces. We have faced assimilation, that ever present 'owl' [death] which will not leave us behind no matter how peaceful our hearts. We have and still face financial difficulties . . . [but] as any society with a long history will teach us, it is overcoming these inner conflicts that brings strength, communication, understanding and continuity to that society." — M.B., Comanche man, 1987.

"A LOT OF US ARE AWARE that . . . when we get out on the job, we have to do what these people do. We have to pick up their ways in order to make it easier for ourselves. When our children go to school, they associate with the majority — colored people, white people, Mexican people . . . — which is good — in order to comprehend something else. Although we don't want them to lose our own culture." — B. J., Choctaw man, 1976.

"THE FIRST PLACE WE headed for was the beach. It was a hot October. . . . The smog was so bad we were literally crying. . . . We saw a little place that said 'rentals' . . . at Hermosa Beach. . . . I think it was \$62 a month. It was beautiful. . . . The next thing we went back to report to the B.I.A. Oh, they were mad at us. Because [we were told], you were supposed to visit [the beaches], not live there. . . . You were sup-

posed to live where they put you — in that dump down out there downtown L.A. And I said, 'If we can afford to live there, we'll live there.' So on our report, they put we were 'uncooperative.'" — T. W., Englishwoman married to a Santa Clara Pueblo man, 1988.

"OUR CHILDREN NEVER got into the problems that many of the children did get into [in the city] because they were involved with their Indian culture and heritage. And it still keeps the same respect that they have on the reservation. Like on [the] reservation . . . people used to come to the door and say that they came to see their aunt or uncle or grandpa . . . But it was just their respectful way of saying everybody was an aunt or uncle. . . . it was a form of respect. . . . It's so nice to hear children talk that way." — T. W., Englishwoman married to a Santa Clara Pueblo man, 1988.

"I'VE BEEN WORKING ON this for years. This has been my dream — to have an Indian Methodist church in Los Angeles. You see, . . . lots of Choctaws and other Indian Methodists don't [feel comfortable in a white church]. Indians want to be with their own people. They're just more comfortable that way. They don't have to dress fancy. They can take their kids to the service. They can have potlucks and serve their Indian food. They can sing their own songs. And Indians love singing. They can sing until

midnight — all night if they want to — in their own churches. They can't do that in the white churches. It just works out better for them having their own church to go to." — L.W., Choctaw woman, 1975.

"MY GRANDMOTHER, IN her wisdom, had the foresight to see that if you were going to be Indian, you're going to be *nothing*. And she just said, 'Well, you don't have to suffer like I did. You don't have to be Indian. You're half white. You're half Indian, so you're going to be given a choice. And I'm going to make that choice for you. You won't have to go through the indignities of having to learn English for the first time when you go to school and in front of all those white kids like I did.' So one day she just quit [speaking the tribal language to her grandchildren]." — T.S., Blackfeet man, 1979.

"I HAD A VERY DIFFICULT time adjusting. Typical Indian. It wasn't so much an Indian cultural adjustment as it was a rural/urban culture adjustment. I couldn't stand the coldness, the size, just a whole different atmosphere socially. The first time lasted about three months. I got a job, made enough for a train ticket home, and that was it. That time I stayed [on the reservation] about six months. When it began to get cold, I realized that I had made a mistake. I did that about three or four times." — T.S., Blackfeet man, 1979.

pottery, rugs, basketry, leather goods, bead and quill work, drums, rattles, and countless other items. Food kitchens offer traditional fry bread, chili, and Navajo tacos alongside Coke, Pepsi, hot dogs, and hamburgers. The Natural History Museum of Los Angeles County's annual American Indian Festival and Market, a descendant of powwow now in its 21st year, attracts artists and craftspeople from all over the U.S. Similar regional markets-cum-folk-celebrations thrive throughout the country.

Several hundred people, mostly American Indians, from as many as 200 different societies regularly attend the city's Saturday night powwows. Held weekly from September to June, they still contain quasi-sacred ritual components (the opening prayer, the flag song, and honoring songs and dances). Ethnic symbolism, both sacred and secular, infuses the powwow food, dancing, drumming, singing, and dance regalia.

Powwows are arenas for the reinforcement of community statuses and roles, for the paying of honor and respect, and for the display of ethnic skills and knowledge. Through their communal and ceremonial acts, powwow dancers express their ideal selves to others who do not, or cannot, share the cultural act but who respect its validity. And, by extension, they express these same ideals for all of the Indians in L.A.

Joan Weibel-Orlando is an associate professor of anthropology at the University of Southern California and the author of Indian Country, L.A.: Maintaining Ethnic Community in Complex Society. She has published widely on ethnic continuity and coping strategies of Navajos and Choctaws in Los Angeles and on drinking contexts and practices in the Los Angeles pan-Indian and rural indigenous California Indian communities. She is producer and executive director of "That Our Voices Be Heard," the film about contemporary Native American life in Los Angeles made for the Times Mirror Hall of Native American Cultures. She has written, produced, and directed documentary films and videotapes and written, produced, and directed documentaries on her subject. Her current research is with aging North American Indians in Los Angeles, Pine Ridge, South Dakota, and southeastern Oklahoma.

All photographs in this article are by Robert A. Orlando, director of clinical laboratories and chief of anatomical pathology at the Beverly Hospital in Montebello and the Whittier Hospital Medical Center. Dr. Orlando, an award-winning photographer, assists Dr. Weibel-Orlando with the illustrations of her books, articles, and ethnographic video productions.

Powwows are held every Saturday night in the Los Angeles area. General attendance is invited. For information, call the Southern California Indian Centers, Inc. at 213/387-5772.



LEFT

Veronica Parrilla, Ute/Navajo, is a familiar face at L.A. powwows. Her dancing has earned her the title of Powwow Princess of the Many Trails Indian Club, along with honors at many dance contests.

RIGHT

Fry bread (bread dough fried in lard or oil and served plain, with fried beans and salsa, or with powdered sugar, honey, or jelly) has been described as the "national food" of contemporary American Indians. No powwow would be complete without a fry bread booth.

Global Warming on Trial

by Wallace S. Broecker

JIM HANSEN, A CLIMATOLOGIST AT NASA's Goddard Space Institute, is convinced that the earth's temperature is rising and places the blame on the buildup of greenhouse gases in the atmosphere. Unconvinced, John Sununu, former White House chief of staff, doubts that the warming will be great enough to produce a serious threat and fears that measures to reduce the emissions would throw a wrench into the gears that drive the United States' troubled economy. During his three years at the White House, Sununu's view prevailed, and although his role in the debate has diminished, others continue to cast doubt on the reality of global warming. A new lobbying group called the Climate Council has been created to do just this.

The stakes in this debate are extremely high, for it pits society's short-term well-being against the future of all the planet's inhabitants. Our past transgressions have altered major portions of the earth's surface, but the effects have been limited. Now we can foresee the possibility that to satisfy the energy needs of an expanding human

population, we will rapidly change the climate of the entire planet, with consequences for even the most remote and unspoiled regions of the globe.

The notion that certain gases could warm the planet is not new. In 1896 Svante Arrhenius, a Swedish chemist, resolved the longstanding question of how the earth's atmosphere could maintain the planet's relatively warm temperature when the oxygen and nitrogen that make up 99 percent of the atmosphere do not absorb any of the heat escaping as infrared radiation from the earth's surface into space. He discovered that even the small amounts of carbon dioxide in the atmosphere could absorb large amounts of heat. Furthermore, he reasoned that the burning of coal, oil, and natural gas could eventually release enough carbon dioxide to warm the earth.

Hansen and most other climatologists agree that enough greenhouse gases have accumulated in the atmosphere to make Arrhenius's prediction come true. Burning fossil fuels is not the only problem; a fifth of our emissions of carbon dioxide now come from clearing and burning forests. Sci-

Hunters in the Snow was painted by Pieter Bruegel the Elder in the winter of 1564-65, one of the most severe of the Little Ice Age.



Kunsthistorisches Museum, Vienna

entists are also tracking a host of other greenhouse gases that emanate from a variety of human activities; the warming effect of methane, chlorofluorocarbons, and nitrous oxide combined equals that of carbon dioxide. Although the current warming from these gases may be difficult to detect against the background noise of natural climate variation, most climatologists are certain that as the gases continue to accumulate, increases in the earth's temperature will become evident even to skeptics.

The issue under debate has implications for our political and social behavior. It raises the question whether we should renew efforts to curb population growth and reliance on fossil fuels. In other words, should the age of exponential growth initiated by the Industrial Revolution be brought to a close?

The battle lines for this particular skirmish are surprisingly well balanced. Those with concerns about global warming point to the recent report from the United Nation's Intergovernmental Plan on Climate Change, which suggests that with "business as usual," emissions of carbon dioxide by the year 2025 will be 25 percent greater than previously estimated. On the other side, the George C. Marshall Institute, a conservative think tank, published a report warning that without greenhouse gases to warm things up, the world would become cool in the next century. Stephen Schneider, a leading computer modeler of future climate change, accused Sununu of "brandishing the [Marshall] report as if he were holding a crucifix to repel a vampire."

If the reality of global warming were put on trial, each side would have trouble making its case. Jim Hansen's side could not prove beyond a reasonable doubt that carbon dioxide and the other greenhouse gases have warmed the planet. But neither could John Sununu's side prove beyond a reasonable doubt that the warming expected from greenhouse gases has not occurred.

To see why each side would have difficulty proving its case, let us review the arguments that might be presented at such a hearing. The primary evidence would be the temperature records that have been kept by meteorologists since the 1850s. A number of independent analyses of these measurements have reached the same basic conclusions. Over the last century the planet has warmed about one degree. This warming was especially pronounced during the last decade, which had eight of the warmest years on record, with 1990 being the hottest. While Sununu's group might question the adequacy of the geographic coverage of weather stations during the early part of the record and bicker a bit about whether the local warming produced by the growth of cities has biased some of the

records, in the end they would concede that this record provides a reasonably good picture of the trend in the earth's temperature. Sununu's advocate would then counter by asking, "Isn't it strange that between about 1940 and 1975 no warming occurred?" The Hansen group would have to admit that there is no widely accepted explanation for this leveling. Sununu's advocate would continue, "Isn't it true that roughly half the warming occurred before 1940, even though almost all the emissions of carbon dioxide and other greenhouse gases have taken place after this date?" Again the Hansen group would have to admit this to be the case.

At this point, a wise judge might pose the following question to both sides: "What do we know about the temperature fluctuations that occurred prior to the Industrial Revolution?" The aim of this question would be to determine what course the earth's temperature might have taken if the atmosphere had not been polluted with greenhouse gases. The answer by both sides would have to be that instead of remaining the same as it was in 1850, the planet's temperature would have undergone natural fluctuations, which could have been as large as the changes measured over the last one hundred years. Neither side, however, would be able to supply the judge with an acceptable estimate of what would have happened to the earth's temperature without the release of greenhouse gases.

Perhaps a longer record of the earth's climate would shed light on its natural variability. The climate prior to 1850 can be reconstructed from historical records of changing ice cover on mountaintops and on the sea. The earliest evidence of this type dates from the end of the tenth century A.D., when Eric the Red first sailed from Iceland to Greenland. Ship logs written between that time and 1190 indicate that sea ice was rarely seen along the Viking sailing routes. The temperature was warm enough that grain could be grown in Iceland. At the end of the twelfth century, however, conditions deteriorated, and sea ice appeared along the Viking sailing routes during the winters. By the mid fourteenth century, these routes were forced far to the south because of the ice, and sometime in the late fifteenth century, ships were cut off altogether from Greenland and Iceland because of severe ice conditions. As temperatures dropped, people could no longer grow grain in Iceland. The Medieval Warm had given way to the Little Ice Age.

After 1600, records of sea-ice coverage around Iceland and of the extent of mountain glaciers in the Alps improved, giving us an even better idea of recent climate change. The glaciers attracted the attention of seventeenth-century tourists, including artists whose drawings and paintings docu-



An engraving made in the 1850s, above, shows the glacier above the French village of Argentière reaching down into the valley.

By 1966, the Argentière glacier, below, had retreated and trees were growing where the ice once flowed.



ment the position of a number of major alpine glaciers. Modern measurements show that the leading edges of these glaciers fluctuated with temperature changes over the last century. Assuming that this correlation held true throughout the Little Ice Age, the historical evidence shows a long interval of glacier expansion, and thus cold climate, lasting until 1860. During the late 1800s, a widespread recession of alpine glaciers heralded the end of the Little Ice Age. Ridges of rock and earth bulldozed into position by the advancing ice still mark the point of maximum glacial progress into the valleys. (The glaciers are still shrinking; less than half of their 1860 volume remains.) The mild conditions that prevailed during the Medieval Warm did not return until this century.

The problem with all this evidence is that it represents only one region of the earth and is, in a sense, anecdotal. An informed judge might also challenge this evidence by pointing out that the northern Atlantic Ocean and its surrounding lands are warmed by powerful ocean currents, collectively known as the Great Conveyor, that transport heat away from the equator. A temporary shut-down of this circulation 11,000 years ago brought about an 800-year cold period called the Younger Dryas, during which northern Europe was chilled by a whopping 12°F. Could the Little Ice Age have been brought about by a similar weakening of the Great Conveyor? If heat release from the northern Atlantic was the key factor, the Little Ice Age would have been restricted to the surrounding region, and the historical evidence from Iceland and the Alps could not be taken as an index of global temperatures.

Although records of similar duration and quality are not available from other parts of the world, we do have firm evidence that by 1850, mountain glaciers in some regions, such as New Zealand and the Andes, reached down into valleys as far as they had at any time during the last 8,000 years. Furthermore, by 1870 these glaciers had also begun their retreat. This suggests that the Little Ice Age was indeed global in extent.

The global warming that caused the demise of the Little Ice Age confuses attempts to estimate how much of the last century's warming is natural and how much has been caused by pumping greenhouse gases into the atmosphere. The Sununu side would pin as much of the blame as possible on the natural warming trend that ended the Little Ice Age, while Hansen's side would emphasize the role of the greenhouse gases. What is needed to resolve this dispute is a detailed, continuous temperature record that extends back beyond the Medieval Warm to see if cycles could be identified. By extending these cycles into the present cen-

Collection Paul Payot, Conservatoire d'art et d'histoire, Haute-Savoie-Denis Rigault

Madeline Le Roy, Ladure/Bibliothèque Nationale

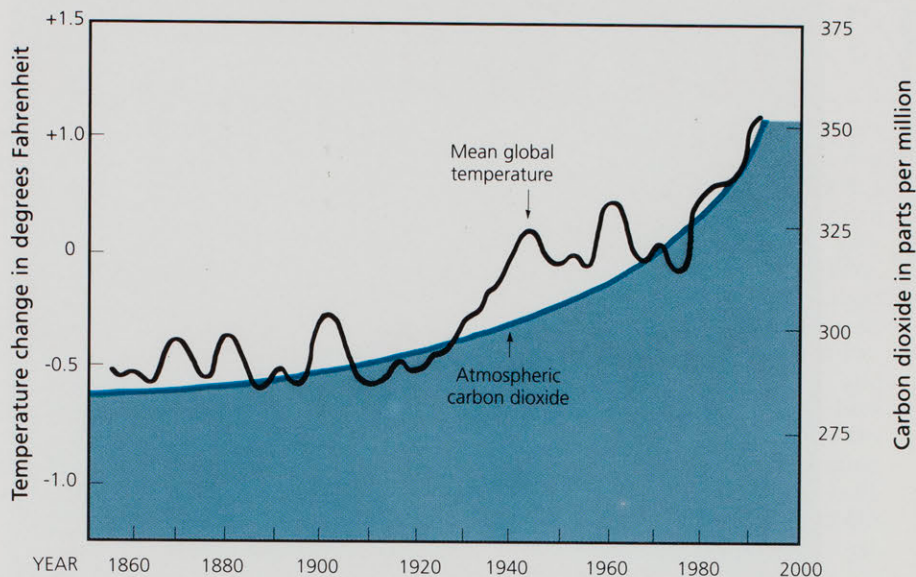
tury, scientists could estimate the course the earth's temperature would have taken in the absence of the Industrial Revolution.

I made such an attempt in 1975, at a time when the earth's temperature seemed to have remained almost constant since the mid-1940s. Puzzled scientists were asking, "Where's the expected greenhouse warming?" I looked for the answer in the only detailed long-term record then available, which came from a deep hole bored into northern Greenland's icecap at a place called Camp Century. In the 1950s, Willi Dansgaard, a Danish geochemist, had demonstrated that the ratio of heavy to light oxygen isotopes (18 nucleons to 16 nucleons per atom, respectively) in the snow falling in polar regions reflected the air temperature. Dansgaard made measurements of oxygen isotopes in different layers of the ice core; each represented the compressed snowfall of an arctic year. His results served as a proxy for the changes in the mean annual temperature. Dansgaard and his colleagues analyzed the record to see if the temperature fluctuations were cyclic. They found indications of two cycles, one operating on an 80-year time scale and a weaker one operating on a 180-year time scale. (The Milankovitch cycles, caused by changes in the earth's orbit around the sun, operate on a much longer time scale. Ranging from 20,000 years upward, these cycles are thought to control the large swings between glacial and interglacial climates.)

I took Dansgaard's analysis a step further by extending his cyclic pattern into the future. When combined with the expected greenhouse warming, a most interesting result appeared. Temperatures leveled off during the 1940s and 1950s and dropped somewhat during the 1960s and 1970s. Then, in the 1980s, they began to rise sharply. If there is a natural eighty-year cycle and it was acting in conjunction with a greenhouse effect, I would explain the leveling of temperature after 1940 as follows: Dansgaard's eighty-year cycle would have produced a natural warming between 1895 and 1935 and a natural cooling from 1935 to 1975. The cooling in the second half of the cycle might have counterbalanced the fledgling greenhouse warming. After 1975, when the natural cycle turned once again, its warming effect would have been augmented by the ever stronger greenhouse phenomenon, producing a sharp upturn in temperature in the 1980s.

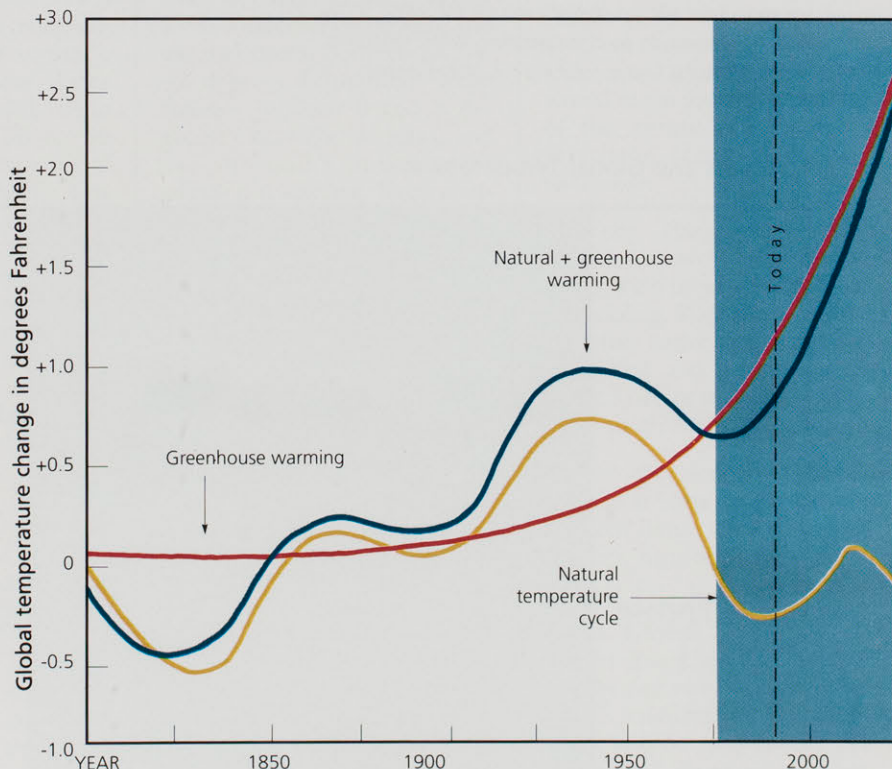
My exercise showed that the lack of warming between 1940 and 1975 could not be used to discount the possibility that the pollution we are pumping into the atmosphere will ultimately warm the globe. We cannot rule out this possibility until that time in the future when the predicted warming is so great that it can no longer be masked

Carbon Dioxide and Global Temperature



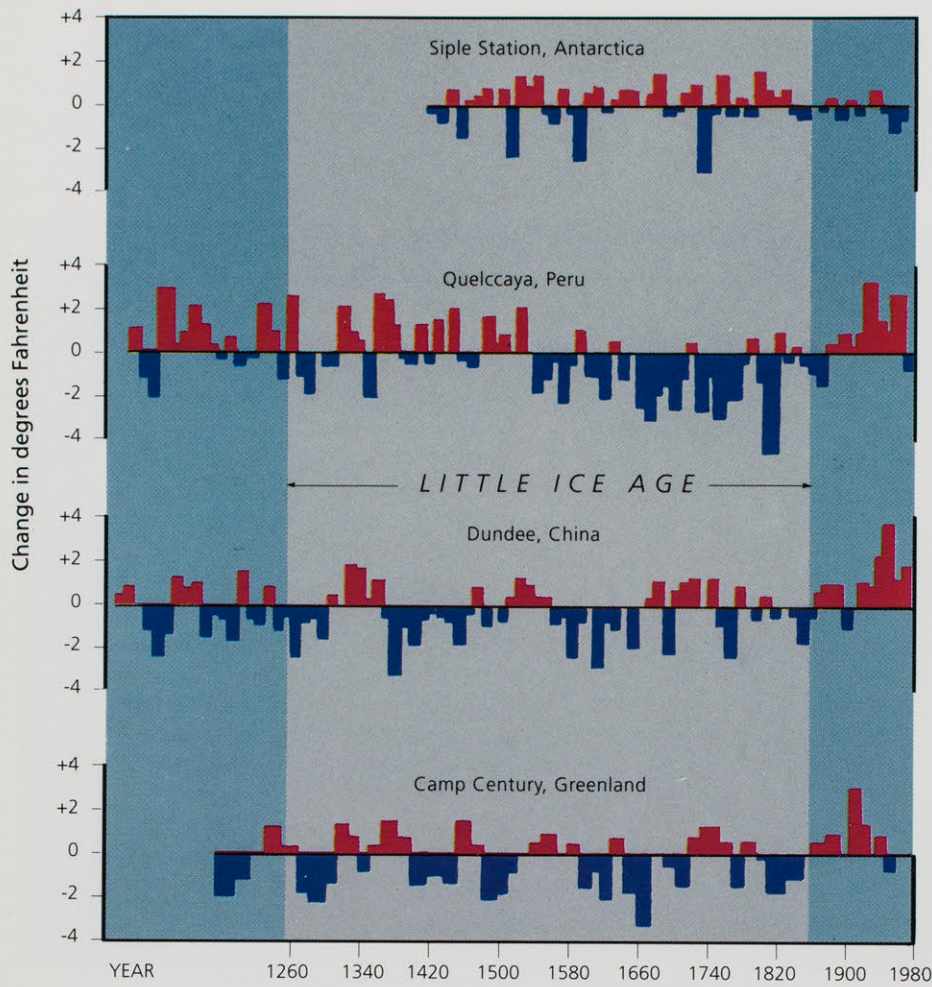
While atmospheric carbon dioxide has climbed steadily for more than a century, the earth's temperature shows a more erratic upward trend.

Predicted Warming from Natural and Human Causes



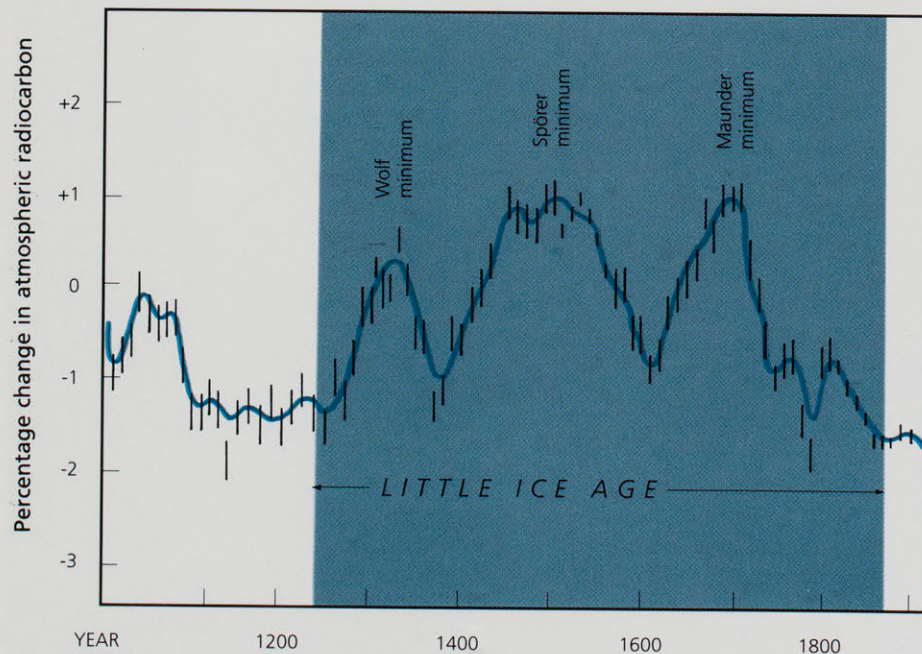
In 1975, the author published this diagram, suggesting that despite a rise in greenhouse gases, the earth cooled somewhat during the 1960s and 1970s because it was at the low point of a natural temperature cycle. He predicted the warming of the 1980s, when the natural cycle again turned upward, no longer masking the effect of the gases.

Temperature Shifts Recorded by Oxygen Isotopes in Ice Cores



Ice cores from various glaciers around the world show little agreement on past temperature shifts, reflecting local conditions that complicate the global record.

Sunspots and Global Temperature



During the Little Ice Age, levels of radiocarbon in tree rings indirectly recorded three periods when sunspots all but disappeared. Sunspot minimums correspond to a slight decrease in the sun's energy output.

by natural temperature fluctuations. My projection suggested that a firm answer will not be available until the first decade of the next century.

While the Camp Century record seemed to provide a good method of determining how natural variations and increasing greenhouse gases were working in concert to produce the measured global temperatures, additional ice core data only created confusion. Oxygen isotope records from ice cores extracted from the Antarctic icecap and mountain glaciers in China and Peru do not follow the Camp Century ice core pattern. Even worse, oxygen isotope records from three additional Greenland ice cores differ significantly from one another and from the original Camp Century record. Perhaps the most disconcerting feature of these ice core records is that the Medieval Warm and Little Ice Age do not even stand out as major features. Local temperature variations could account for these discrepancies, but oxygen isotope ratios also depend on the season the snow falls and the source of the moisture. For these reasons, ice cores may provide good records of large changes, but the smaller ones we are looking for over the last several hundred years are obscured.

At this point, the judge would likely lose his patience and call a halt to this line of argument, saying, "While regional climate changes certainly occurred during the centuries preceding the Industrial Revolution, firm evidence for a coherent global pattern in these natural fluctuations is lacking." The judge might then suggest a different approach to settle the question of whether we are causing the earth to warm. What drives the natural changes? If we could pin down the villain, then perhaps we could say more about how temperature would have changed in the absence of the Industrial Revolution. Witnesses would point to three such mechanisms. First, the sun's energy output may have changed. Second, large volcanic eruptions may have injected enough material into the stratosphere to reflect a substantial amount of solar radiation back into space, cooling the planet. Third, the operation of the ocean-atmosphere system may have changed internally, causing the earth's temperature to wander.

For several centuries astronomers have been observing the cycles of the sun and trying to link them with climate patterns on earth. Sunspots, caused by knots in the sun's magnetic field, undergo cyclic change, alternating between a maximum of spots in the Northern Hemisphere and then a maximum in the Southern Hemisphere. Between these peaks, the number of sunspots drops almost to zero. A complete solar cycle takes twenty-two years. With satellites, astronomers have been able to directly monitor the sun's energy output over the

Things You Can Do . . .

ON AVERAGE, EVERY American releases about 20 tons of carbon dioxide into the atmosphere each year. The figure includes transportation and home energy use, but not industrial and government production. The book *Fight Global Warming: 29 Things You Can Do*, published by Consumer Reports Books and the Environmental Defense Fund, contains a table for estimating families' production of carbon dioxide. The following suggestions, extracted from the book, describe some ways of cutting energy consumption:

- Whenever possible, walk, bike, carpool, or use mass transit. The average American car emits 7.5 tons of carbon dioxide per year (based on 15,000 miles). A 10% increase in commuters who carpool would save 7.5 million gallons of gasoline per day.

- Certain driving practices can improve fuel efficiency, beginning with the purchase of a high-efficiency automobile. Other measures: avoid "jack-rabbit" starts; use air conditioning sparingly; use radial tires; have regular tune-ups; don't idle the engine unless necessary; keep air filters clean; don't carry extra weight in the back or trunk. Automobile air conditioners put more chlorofluorocarbons into the atmosphere than any other single source, so have leaks repaired. Refrigerant must be recycled.

- One-third of the heated air in a home is lost through windows. Weatherization — weather stripping windows and doors, installing drapes with valences to trap air, and caulking are small investments that

can save energy. Lower thermostat settings also help; every two degrees cuts carbon dioxide emissions related to heating by six percent.

- Use a fan instead of an air conditioner. Fans use one tenth the energy of air conditioning. If you do use air conditioning, keep the unit shaded from the sun, close off vents to rooms that don't need cooling, don't set the thermostat too low, and keep coils clean and straight.

- Hot water is one of the easiest things to abuse — and one of the easiest to conserve. Lower the temperature setting on your hot water heater and wrap your heater in an insulating blanket. Install low-flow showerheads (those with aerators compensate for the reduced volume). "Demand" units heat water only when it is needed, at an energy savings of 20 to 30 percent over conventional tanks. California's Pacific Gas and Electric calculates that two low-flow aerators, in the kitchen and bathroom sinks, would save a family of four up to 3,300 gallons of water a year — not to mention the energy needed to transport, filter, and otherwise treat the water both before and after it finds its way to household taps.

- Wash clothes in warm or cold water; always rinse in cold water. Wash only full loads; use the "delicate" setting, which consumes less electricity.

- Don't overpack clothing in a dryer, or overdry it; use a clothesline for items that don't need the benefits of a dryer.

- Run dishwashers only when fully loaded, and let dishes air dry. Newer dishwashers have units that heat incoming water as it is needed.



- Buy energy-efficient appliances. Energy Guide labels give estimates of yearly energy cost or help individuals estimate their own use.

- The refrigerator is the appliance that consumes the most electricity in the home. Purchase an energy-efficient model. Keep condenser coils clean, and the thermostat between 38 and 42 degrees Fahrenheit. Keep freezers between 0 and 5 degrees. Check for air leaks, and use the unit's power-saver switch if it has one. Keep compartments full (food retains cold better than air does), and let hot foods cool before refrigerating them. Unplug second refrigerators that are seldom used.

- Standard incandescent light bulbs last 750 to 1,000 hours and account for over 100 pounds of carbon dioxide during that time. Only about 10 percent of the energy such a bulb uses makes light; the rest is lost as heat. Far more efficient are compact fluorescent lights, which last ten times longer and consume one-fourth the power. They cost more, but in fixtures that receive a lot of use they can save money. Replace the three most-used bulbs at home with compact fluorescent ones, and keep all bulbs dust-free: dust can cut luminosity by ten percent (white walls reflect more light, too). Turn off lights not in use.

- Recycling makes sense even without global warming, but if products made of plastic, glass, aluminum, containerboard, and paper are turned back into what they were before, energy savings result, leaving more resources available for other uses. Buy goods that can be recycled or reused, and choose products with less packaging.

- Eating less red meat can reduce the size of cattle populations, reducing methane emissions from bovine manure and flatulence. In addition, cattle eat much of the corn grown in the U.S.; reduced corn production would mean lowered emissions of the nitrous oxide used in fertilizer (corn is heavily fertilized).

- Trees consume carbon dioxide, as well as providing shade, wind breaks, and evaporative cooling. Plant drought resistant trees native to the area that grow fast and provide ample shade. Local or state forestry officials can give recommendations.

- Take the same measures at work as at home: change to fluorescent fixtures, monitor thermostats, turn off lights, and recycle.

Fight Global Warming: 29 Things You Can Do, copyright 1991 by the Environmental Defense Fund, published by Consumers Union of U.S., Inc., Yonkers, NY 10703-1057. Excerpted by permission from Consumer Reports Books. *Fight Global Warming: 29 Things You Can Do* will be available in the museum's bookshops during the exhibit *Global Warming: Understanding the Forecast*.

A nearly continuous expanse of the Amazon's tropical forest (red in false color imagery) is visible in this 1973 Landsat Multispectral Scanner mosaic of Rondônia in Brazil, top. The area shown is roughly equivalent to the New England states. Before completion of the Cuiaba-Porto Velho highway (the faint diagonal line crossing the mosaic) in 1968, Rondônia was a remote federal territory, home to rubber tappers and prospectors, and only accessible by small aircraft or riverboat.

A 1991 mosaic, bottom, reveals Rondônia's changing pattern of land use. The "fishbone" pattern is the result of land clearing by farmers along secondary roads that branch off from the highway. In the 1970s and 1980s, government programs encouraged farmers to migrate to Rondônia from overcrowded and drought-stricken regions. Porto Velho, the capital of Rondônia State, is visible at the intersection of the highway and the Rio Madeira, a major tributary of the Amazon River. Suspended sediments, the result of soil erosion, now highlight the river. Deforestation of the Amazon is a global issue, as a fifth of our emissions of carbon dioxide now come from clearing and burning forests. Mosaics courtesy of the Brazilian National Space Research Institute (INPE), São José dos Campos, SP, Brasil. Photographed by Frederick C. Engle.

last cycles. Although the energy seems to dip slightly when sunspots disappear, the change seems too small to greatly alter the earth's temperature.

An intriguing proposal was recently made in this regard. Two Danish meteorologists, Eigil Friss-Christensen and Knud Lassen, point out that over the last 130 years for which observations are available, the sunspot cycle has lengthened and shortened with a periodicity of about 80 years, and that these changes closely parallel the earth's temperature. The Danes suggest that during intervals when the sunspot cycle is longer than average, the sun's energy output is a bit lower, and that when the cycle is shorter, the energy output is higher. Could it be that Dansgaard was correct in thinking that the earth's temperature changes on an eighty-year time scale and that these changes are driven by the sun? Most scientists remain skeptical because no physical mechanism has been proposed tying solar output to the length of the sunspot cycle. Others say that the strong similarity between the length of the sunspot cycle and the earth's temperature could be a coincidence.

In addition to the twenty-two-year solar cycle, however, change on a longer time scale has been documented. Between 1660 and 1720, sunspots disappeared altogether. Auroras, which are created when charged particles driven out from the sunspots enter the earth's upper atmosphere, were also absent from the skies during this period. Further, we know from measurements of carbon 14 in tree rings that this radioactive element, produced by cosmic rays bombarding the atmosphere, increased substantially during this time. Normally, charged particles streaming outward from sunspots create a magnetic shield that deflects cosmic rays away from the earth and the inner planets. From 1660 to 1720, this magnetic shield failed, permitting a larger number of cosmic rays to strike our atmosphere and form an unusually large number of radioactive carbon atoms.

From the record of radiocarbon locked up in tree rings, we can identify two even earlier periods of reduced sunspot activity: the Wolf sunspot minimum, from about 1260 to about 1320, and the Spörer sunspot minimum, from about 1400 to 1540. These three periods span a major portion of the Little Ice Age, but the last ended more than a hundred years before the Little Ice Age did — too long a time lag. This mismatch in timing and the small change in the sun's energy output (as measured by satellites over the last solar cycle) make a link between the Little Ice Age and the absence of sunspots unlikely. But the partial match prevents a firm rejection of the sun as a cause of the earth's natural temperature changes.

What about volcanic eruptions? Major volcanic eruptions occur roughly once per decade.

Most have little effect on the climate, but occasionally an eruption blasts a large volume of sulfur dioxide high into the stratosphere. Within a month or two, the sulfur dioxide is transformed into droplets of sulfuric acid, which remain aloft in the stratosphere for a year or more. These tiny spheres reflect sunlight away from the earth, cooling the planet. Hansen and his colleagues predict that the recent eruption of Mount Pinatubo in the Philippines (which shot more sulfur dioxide into the upper atmosphere than any other eruption this century) will cool the planet about one degree Fahrenheit by early 1994.

Could the Little Ice Age have been caused by 500 years of intense volcanism releasing copious amounts of sulfur dioxide? This seems implausible, as the world's 100 or so major volcanoes erupt independently of one another and no mechanism exists that could cause them all to erupt with greater frequency. Therefore, the chance is slim that one long interval would be followed by a similar period of lesser activity.

Fortunately, a record is available in ice cores to check this assumption. When the droplets of sulfuric acid from a volcanic eruption drift down from the stratosphere, they are quickly incorporated into raindrops and snowflakes and carried to the earth's surface. So, in the years immediately following a major volcanic eruption, snow layers rich in sulfuric acid are deposited on all the world's icecaps. An ice core taken from the Dye 3 site in southern Greenland reveals that at about the time of the transition from the Medieval Warm to the Little Ice Age the acid content in the ice doubled. On the other hand, low acidity from 1750 to 1780 (during a time of cold weather) and the relatively high acidity from 1870 to 1920 (when the climate was warming) do not fit the pattern of climate change. Therefore, no strong correlation exists between the trends in volcanic sulfur dioxide and the trend in the earth's temperature.

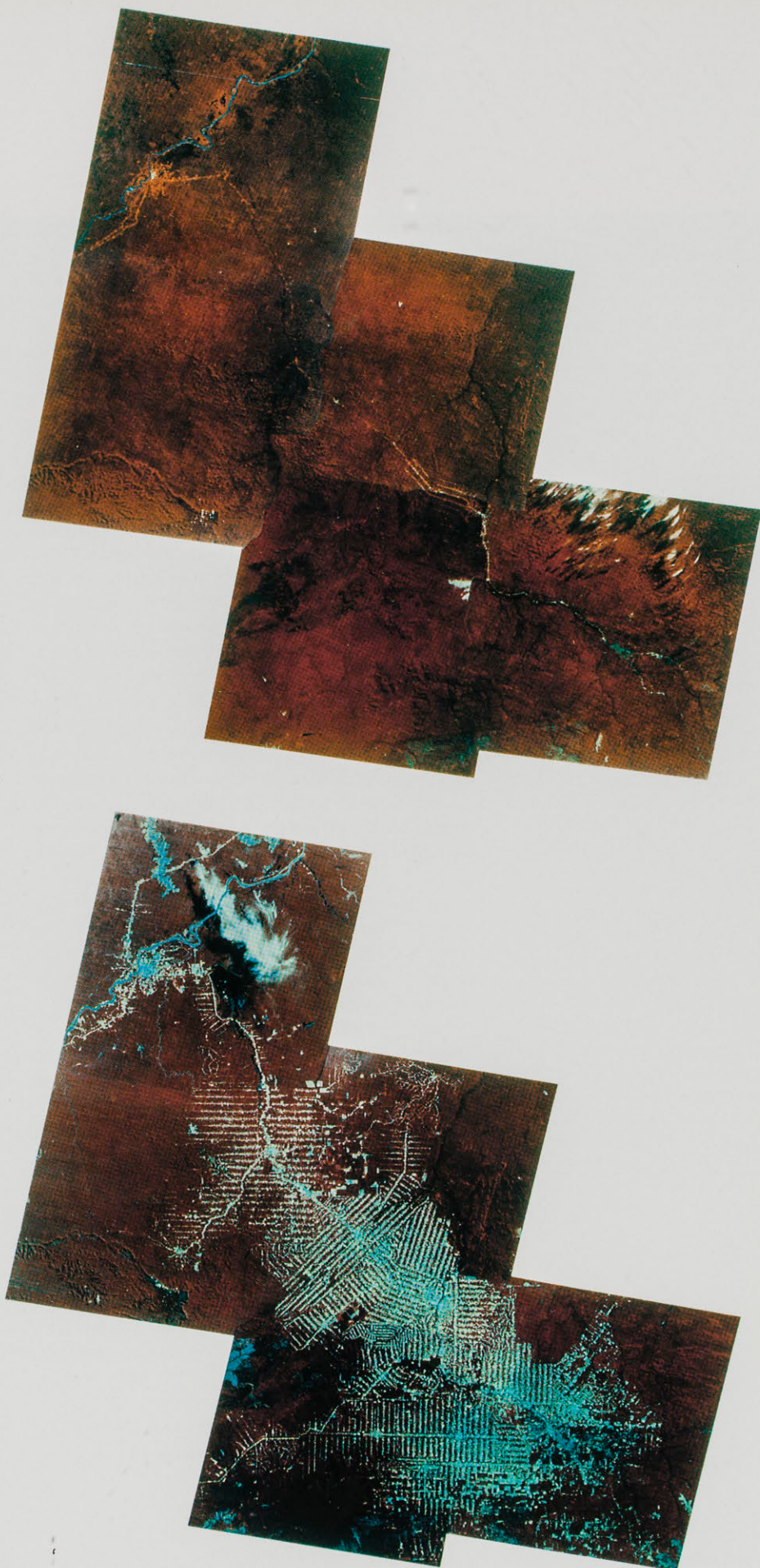
The last of the three mechanisms that might account for the natural variations in the earth's temperature is a dramatic shift in the way the planet's ocean and wind currents operate. Of the three mechanisms, this one is the hardest to build a case around because we have only a rudimentary understanding of how the interacting elements of the earth's climate system might cause natural fluctuations in temperature. The only well-documented example of such a mechanism is the El Niño cycle, in which winds and ocean currents cause the temperatures of the surface waters of the eastern equatorial Pacific to alternate between warm and cold. The cycle was first noticed because of the severe drops in fish production along the west coast of South America during the warm epi-

sodes. Since the timing between these disruptive events ranges from three to seven years, scientists became interested in predicting their arrival. What emerged from these studies is that El Niño cycles are the product of a complex interaction between winds and ocean currents. The importance of this discovery to the global warming debate is that it raises the possibility that cycles involving larger-scale interactions between the atmosphere and oceans — over longer periods — may play an important role. If the earth's temperature is being pushed up and down by such an internal cycle, our chances of determining what would have happened in the absence of the extra greenhouse gases are indeed slim.

Again the judge would become restive and call a halt to this line of evidence as well. At this point he would likely dismiss the case and suggest that the litigants return a decade from now when additional evidence regarding the warming trend has accumulated.

Sununu would deem this decision a victory, for it would provide an excuse to delay actions directed toward reductions in carbon dioxide emissions. On the other hand, Hansen could surely maintain that in the absence of proof that the world is not warming at the rate predicted by computer simulations, we should follow the standard applied to other environmental threats and rule on the side of caution. Instead of placing the burden of proof on the environmentalists, the proponents of "business as usual" should be obliged to prove that the unfettered release of greenhouse gases will *not* significantly warm the planet. And such proof does not exist; the balance of scientific opinion is that business as usual will alter the climate.

The debate over global warming is merely a small skirmish that marks the beginning of a far broader war. Many of the things that we could do to curb the buildup of greenhouse gases — such as conserving energy, switching to renewable energy sources, or increasing our use of nuclear power — will be stopgap measures if the underlying problem of population growth is not addressed. World population is now 5.5 billion and growing by about 1.8 percent every year. If this rate is not substantially reduced, world population will double by the year 2030. If by that time the rate of population growth has not been greatly reduced, we run the risk that the population will skyrocket to 20 billion or more before it finally levels off. Each additional person adds to the pressure to increase the use of fossil fuels, pumping ever larger amounts of carbon dioxide into the atmosphere. In countries such as the United States and Canada, where per capita energy consumption is the highest in the world, each person, on average, adds twenty tons of car-



bon dioxide a year to the atmosphere. In developing countries, where most of the population growth will occur, per capita energy consumption is much smaller, with less than three tons of carbon dioxide emitted per person. But as these countries strive to better the lot of their citizens through industrialization, their energy demands will climb. Most of the increase will be met by burning fossil fuels, particularly coal, which releases more carbon dioxide per unit of energy produced than oil or gas. Therefore, annual emissions of greenhouse gases are likely to increase.

We are rapidly approaching a limit beyond which we cannot maintain our numbers without long-term damage to our planet's environment and its remaining wildlife and to the quality of life of its human populations. While Sununu may be particularly shortsighted with regard to the effects of greenhouse gases on the climate, most of the world's leaders are shortsighted with regard to the population problem. They seem to ignore it completely. I hope the concern about global warming will force us to develop a broader perspective of our planet's future — one that will include the reality of the population bomb. Only then will we be able to begin the extraordinarily difficult task of defusing it.

Wallace Broecker is a Professor of Geochemistry at Columbia University's Lamont-Doherty Geological Observatory. His interests are in the link between ocean circulation and global climate. He is a member of the National Academy of Sciences.

This article was reprinted with permission from Natural History, April 1992. Copyright the American Museum of Natural History, 1992. Graphs were designed by Joe Le Monnier, courtesy of Natural History magazine.

The photograph on the inside front cover of TERRA, documenting deforestation of the Brazilian rain forest, appears in the book Embracing Earth, by Payson R. Stevens and Kevin W. Kelley. Embracing Earth, which uses satellite images and discussion of the technical information in them to show how humans have affected the balance of nature, is available in the museum bookshop.

The editors thank Frederick Engle of the National Air and Space Museum of the Smithsonian Institution for his contributions to this article.

The Costs of Prevention

by James K. Hammitt

ONE OF THE OBSTACLES to the prevention of global warming is that it is a "commons problem," exemplified by the proverbial common pasture. An individual shepherd who removes one of his sheep loses wool, milk, and other products, while the benefits of his sheep's absence — more forage for the remaining animals — are shared by all. Similarly, since the costs of reducing emissions of carbon dioxide, methane, nitrous oxide, and other greenhouse gases (GHGs) fall on the nations that choose to reduce them, but the benefits of reduced global warming are shared by all, nations have inadequate incentives to control their emissions.

Another difficulty in preventing global warming is the long delay between when costs are incurred and benefits reaped. Global warming may not show significant consequences for decades, so the benefits of preventing it lie far in the future. Government officials, bound to electoral cycles, have limited incentives to impose costs on their nations to prevent this distant and unproven threat. A nation that restricts its use of fossil fuels or takes other actions to limit its own GHG emissions may also find itself at a competitive disadvantage. Some nations, however, Japan and Germany among them, see commercial opportunity in GHG-limiting technologies.

Two kinds of responses to global warming, abatement and adaptation, are worth considering. Abatement (or prevention) includes actions like reducing GHG emissions (by substituting nuclear or photovoltaic for coal-fired electrical generating

plants, for example) and increasing absorption of GHGs from the atmosphere (by reforestation). Abatement also includes "geo-engineering" measures like fertilizing the southern oceans with iron to enhance biological uptake of carbon dioxide, or reducing incoming solar radiation using orbiting mirrors or aerosols lofted into the atmosphere. Not surprisingly, the feasibility and side effects of such measures are highly speculative at present.

Adaptation involves minimizing the damages of global warming, for example by developing new crop strains appropriate to higher temperatures and lower rainfall, or building seawalls to protect against rising sea levels. Because the climate system has significant inertia (carbon dioxide remains in the atmosphere for centuries and the world oceans are a massive heat sink), abatement measures must be taken before global warming reaches serious levels, but adaptation may be delayed until the actual changes to which we must adapt become clearer.

The costs of mitigating climate change are the topic of ongoing research in government agencies, universities, and other research organizations. Most attention has focused on the costs of abatement, in particular by reducing emissions of carbon dioxide and other GHGs. Estimates vary, running the gamut from very small and even negative costs to ones representing appreciable percentages of a nation's Gross Domestic Product (GDP).

Cost estimation is inherently difficult, as it requires information about the magnitude of current emissions from industry, transportation, and other sectors, future emission growth rates, technologies and behavioral changes that would reduce

emissions, and the current and future costs of implementing such changes. The rate at which cuts are made would affect cost as well, since rapid reductions would require scrapping or retro-fitting existing automobiles and other equipment.

The two basic frameworks used for estimating the cost and feasibility of emission reductions — engineering-cost and econometric — tend to produce conflicting results.

The engineering-cost approach identifies specific technologies — such as improvements in heating, cooling, and lighting systems — for providing goods and services while emitting less, and estimates the cost of adopting them. Overall assessments using this framework tend to be relatively optimistic, suggesting substantial reduction of GHG emissions at low cost or even savings.

The econometric approach infers from past behavior how emissions change with changing prices, industrial structure, and other conditions. The oil-price shocks of the 1970s provide a useful perspective on how energy use responds to price changes. The historical rate of technological progress in increasing energy efficiency can also be estimated. This approach tends to produce more pessimistic estimates of the cost and feasibility of emission reductions.

Both approaches have weaknesses. The engineering-cost approach often fails to recognize the extent to which real-world equipment and its operation may not correspond to "best practice," the costs and time required to persuade firms and individuals to adopt new technologies and learn to operate them, qualitative differences in the goods and services produced (although one may reach his destination by city bus or private

automobile, the automobile is often preferred for convenience, privacy, and speed), and possible "rebound" effects when increased energy efficiency leads to greater consumption (when air-conditioning efficiency increases, more people may migrate to sunbelt climates that require it).

The econometric approach typically assumes firms and consumers are perfectly informed about technological opportunities and are making optimal choices among them, so almost by definition it cannot identify opportunities for reducing emissions that also save money. Moreover, because it generally uses gross measures of production, energy consumption, and other factors, this approach cannot provide the technological detail that the other approach can, and the experience on which it is based may be of limited relevance if technologies change rapidly.

A number of econometric and engineering-cost models have been developed to analyze U.S. carbon dioxide emissions (emissions from other nations and of other GHGs have received less attention). According to these models, emissions are expected to increase about 10 to 30% above their 1990 level by 2010. To reduce emissions to 20% less than their 1990 level by 2010, and hold them to that level, would cost 1 to 3% of GDP per year. (Such a reduction, even if extended globally, would slow but not halt the atmospheric buildup of GHGs.) Some technological analyses have concluded that emission reductions of this magnitude could be achieved at virtually no cost, however. In general, estimated costs are higher for deeper and faster emission reductions and fall over time because of adjustment and technological innovation.

The difficulties in estimating economic damages are even greater than those in gauging costs, and few comprehensive estimates have been produced. It is generally thought that damages may be greater in developing countries, as a large share of economic activity in industrialized nations is relatively unaffected by climate. The most frequently cited estimate is from William Nordhaus, a Yale economist, who estimates that annual damages associated with global warming of 3° Celsius (5.4° Fahrenheit) might approximate 1% of GDP in the U.S., and perhaps as much as 2% of economic output globally.

What then should be done? The great uncertainties about the extent to which climates will change, the consequences and economic damages if they do, and the costs of preventing change argue for postponing costly precautions until the problem is better understood, but climatic inertia means that delay may limit the feasibility and increase the costs of abating climate change. Perhaps the best strategy involves some precautionary spending to reduce emissions now, combined with the development of technologies and plans for rapid emission reductions later.

James Hammitt is a Senior Mathematician at RAND. He is currently studying the effects of scientific uncertainty on the design of environmental policy.

Tale of a Ravaged River

THE CANTARA SPILL ON THE UPPER SACRAMENTO

by Eric G. Barham

TWO HOURS BEFORE MIDNIGHT on Sunday, July 14, 1991, a Southern Pacific freight train, grinding up-grade through the first giant hairpin-bend of the infamous Cantara Loop, suddenly "takes up slack" while part of its 97-car string is still athwart a curved trestle. That span, site of previous accidents, is the last river crossing along the Sacramento River Canyon Route. Literally pulled from the tracks, a pusher locomotive and six cars are derailed. The accident has come to be known as the "Cantara Spill," or in official terms, the "Cantara Incident."

One car, a tanker, lies on its side in the middle of a shallow pool, its liquid cargo hemorrhaging through two gaping holes. The car is unmarked as carrying hazardous material. Thus it is broad daylight before the full potential of the impending disaster is realized. While the proper authorities are being notified and salvage equipment and personnel are en route, some 19,000 gallons of metam sodium, a broad-spectrum soil sterilizer, is mixing with the cold, pure waters of the upper or "little" Sacramento River.

THE POISON

Who had heard of metam sodium before reading news stories on the spill? Not this writer. But based on available information, metam sodium is a synthesized organic compound used before planting annual crops to kill nematodes, insect larvae, fungi, and weed seeds in the soil. The straight-chain molecule is made up of methyl and amine-like radicals linked to carbon disulfide. This configuration is ionically bonded to a metallic sodium atom. In its manufactured aqueous form, metam sodium is inert and relatively benign. Unfortunately, therefore, it falls through the cracks of government rules regulating shipment of hazardous products.

Metam sodium's behavior in soil is well-documented, but its reactions under other conditions are little understood. This much is known: when diluted with large quantities of water, the pussycat turns into a tiger. Metam sodium violently takes up water as the highly active sodium atom cleaves a water molecule by bonding with the hydroxyl radical (-OH) to form sodium hydroxide, commonly known as lye or caustic soda. Left behind is the water molecule's remaining hydrogen ion (H⁺), which fulfills the unsatisfied sulphur bond. The resulting "metam" part of the original molecule is unstable and immediately breaks down into the primary killer substances: hydrogen sulfide, the well-known rotten-egg smelling toxic gas; and methylisothiocyanate, (hereafter abbreviated to MITC; see illustration, page 31).

Because of the violence of the above reaction, part of MITC fumes into the atmosphere, but

unless carried by strong winds, its molecular weight holds it close to the ground. The majority of MITC mixes through the water column. Again, because of its specific gravity, in quiet water part can sink into the gravel and contaminate the shallow aquifer. Hydrogen sulfide has a half-life of about five days; MITC continues to slowly disintegrate into other compounds, some being mildly poisonous. The role or fate of the sodium hydroxide is not defined in the available references. In high concentrations it could be deadly, but very likely it would be quickly diluted. In backwater pools, however, hydrogen sulfide could have contributed to the complaints of skin burns and rashes reported by cleanup workers. Degraded to sodium, it would be beneficial to the environment.

The above is probably more than most of us want to know about the chemistry of metam sodium. The bottom line is that the accident created a massive chemical reaction, a green-tinted devil's brew that quickly mixed with the river's volume and formed a gigantic plume some ten miles in length (see illustration, page 30). The "Green Blob," as it was labeled by the news media, flowed downstream, emitting a noxious, gaseous halo into the atmosphere. The measured concentration of toxins in the plume was about 1,500 times greater than the established lethal dosage for the larger forms of the river's animal life.

At the time of the accident, the river's flow at the Cantara trestle was about 45 cubic feet per second (cfs). That is well over one million gallons per hour — a small river but still a huge head of water. There was no practical way of quickly stanching or even diminishing the river's flow. The Green Blob was on its way to Shasta Reservoir.

Downstream residents reported that there were essentially two Green Blobs, a smaller initial pulse followed by the major concentration. Such a sequence may have resulted when salvage operations raised the damaged car and accelerated the drainage of its cargo. There was, however, no official statement from the Southern Pacific Transportation Company as to actions and events immediately following the accident, or for that matter, as to the cause of the derailment. Early news stories mentioned a surging pusher-engine and uneven weight distribution adjacent to the derailed cars. There was even some confusion over the approximate volume of metam sodium spilled. The numbers cited range from 13,000 to 19,500 gallons. The phones of local Southern Pacific managers were essentially "off the hook" in the days following the spill. A definitive accounting is years away and mired in the suck holes of legal actions.

Briefly, that is the birth of the Cantara spill on the Little Sacramento River, one of the worst man-made ecological disasters in California's history.

OPPOSITE

The Cantara Loop trestle was the site of the derailment of a Southern Pacific rail tanker carrying the soil sterilizer metam sodium. On the morning following the derailment, the white metam sodium tank car lay on its side, midstream in the Little Sacramento River. Four months later, a much diluted but still strong pocket of metam sodium breakdown products was discovered in the shallow gravel below the trestle. Traces of toxins were also found in plant tissues, and people were warned about burning fall leaves.



MDW 103

30

C. M. HUBER
ESTD 1974

73' 0" BETWEEN
HEADS

WARNING!

CAN HIT FALL OVER

THE CANYON ENVIRONMENT

The canyon of the Sacramento River, cut through metamorphosed sedimentary and volcanic bedrock, extends northeasterly from the foothills of California's Great Valley, pointing the way, as it were, to the Cascades, the Siskiyou, and beyond. Intertwined with the river along most of its 50-mile length is the principal route connecting California with the Pacific Northwest: Interstate 5 and the main line of the Southern Pacific Railroad (see map).

Deep on the canyon floor, the railroad bed closely follows the river's narrow flood plain. Frequently, the rails must tunnel through rock or span the stream as sheer cliffs block passage on the inside of major turns. The last crossing is the Cantara trestle. Construction of this difficult section delayed completion of the canyon route until 1886.

Interstate 5 and the Sacramento River first meet as the Sacramento arm of Shasta Reservoir slips unobtrusively under the freeway. Some 40 miles upstream, freeway, river, and railroad converge deep in the canyon at the I-5 bridge that divides the town of Dunsmuir into two parts. From this point, the rail bed hugs the western edge of the river until the Cantara trestle is reached, while the highway goes its separate way.

Interstate 5 is cut into the westerly hillsides with ups and downs, but its niche remains aloof, always above the river by several hundred feet. Despite the constant jockeying for space with 18-wheelers, the drive remains one of the most scenic in the American west, and is especially impressive when traveling northward through hundreds of miles of flatland valleys. Motorists are surrounded by timbered hillsides slowly changing from the foothill flora of digger pine/blue oak/chaparral to the yellow pine/incense cedar/black oak transition zone as the road slowly gains elevation. The higher hillsides are dominated by Douglas firs on the western hills and deciduous oaks on the steeper, opposing side. In spring, red bud, dogwood, and wild lilac are in festive bloom and a feral sweetpea is rampant.

But in all seasons it is the mountains that dominate the viewer's senses. On a clear day, driving north on Interstate 5, one gets glimpses of Mt. Shasta's snow-covered crest from 100 miles away. Proceeding up the canyon, each glimpse is more impressive. Barely less impressive are the unique Castle Crags, a skyline montage of wind and water-sculptured granitic boulders.

Northward on Interstate 5 from the Dunsmuir Bridge, a long, steep grade quickly forces 18-wheel rigs, trailers, and motor homes into

the right-hand lanes. The grade tops out at the Highway 89 off-ramp, where one has the best view of the Upper Sacramento's headwaters.

THE RIVER AND THE PEOPLE

Nestled in a valley below is a jewel of a small lake, fed by the three headwater forks of the Little Sacramento draining down the eastern slopes of the Trinity Divide. Lake Siskiyou, as this small impoundment is named, is formed by Box Canyon Dam, built some 20 years ago with state money to create a recreational resource (as an "afterthought" a small hydroelectric plant was appended to the dam by Siskiyou County).

Following a robust spring spate, the river shapes up, usually by late June or early July, and in the upper sections maintains relatively level flows and ideal temperatures (50-60 degrees F.) for trout throughout the long, hot summer. The lower sections of the river, from Slate Creek at La Moine to Lakehead, with their low-velocity flow and warm water, are more to the liking of bass and native fishes than trout. The physical parameters of the lower section are strongly affected by the water level in Shasta Reservoir.

Along the river's 47-mile course, at least 12 major tributaries feed into the main stem. There are also numerous springs, some forming spectacular waterfalls and cascades, while others are small, covert trickles and seeps. It all adds up; during the low-water summer months, from its 40 cfs flow at Box Canyon Dam to its last gauging station at Delta, the water volume has increased some six-fold, to an average flow of 250 cfs. Long-term yearly averages are at least three times that volume.

These are impressive numbers, yet the Little Sacramento is the least of the three major streams forming Shasta Reservoir and its outflow, the "Big" Sacramento. The Little Sacramento drains only 425 miles, compared to 604 and 4,952 for the McCloud and Pit rivers respectively. The Little Sacramento's volume also ranks last, contributing just 18 percent of the total flow, while the Pit contributes 57 percent.

Approximately 3,000 people live within the narrow corridor of the Little Sacramento. The vast majority are concentrated along a ten-mile stretch that runs between the major centers of population, Dunsmuir and Castella. Part of that population lives within a short distance of the river. Some homes are even built on the river's edge, with sun decks extending over the water. During the summer months, most inhabitants sleep with their windows open to allow the refreshing, cool river air to waft through their homes.

THE GREEN BLOB

On that midnight of July 14, there was no Cantara Loop Paul Revere to gallop madly down I-5 to warn the townspeople of the coming toxic plume. The worst of the Green Blob passed through the heavily populated areas of Dunsmuir at about 6:00 AM on a Monday morning, while many people were still abed. It was like a tear gas bomb had been rolled into their dugout.

In the aftermath, near-river inhabitants fled to the school grounds perched high on a hill above the town. At least 400 people sought medical attention, mainly for inhalation of sulphur dioxide fumes and the gaseous form of MITC. Four were hospitalized. Interstate 5 was closed to all but essential traffic.

Sweetbriar, a small enclave of some 60 homes six miles downstream from Dunsmuir, is the most southerly human aggregation along the upper river. Late on the morning of July 15, a group of children were splashing and playing in the river's community swimming hole near a bridge from which hatchery trout are planted. Suddenly, they saw a huge trout thrashing at the surface; they later claimed that it was well over two feet long. The trout swam up on a gravelly shoal, gasping. Repeatedly, the well-meaning children tugged the fish back into deep water, only to have it swim ashore again. Then the pool came alive with trout leaping from the water, swimming ashore. (River trout are highly territorial. When threatened or stressed, they do not dash downstream, but seek cover of the deepest available water.) Parents, alarmed by the discolored water and pervading odd odor, ordered their offspring from the pool.

At last, the alarm was sounded by a volunteer fireman from upriver who drove through the community, admonishing residents to get out. People gathered their kids, threw gear into their cars, and headed south.

THE BATTLE

Along with the evacuees, the Green Blob moved downriver, but at a much slower pace. Death and potential lethal contamination were left in its wake.

As the plume neared Shasta Reservoir, the huge well-head of the Federal Bureau of Reclamation's Central Valley Project and the major source of developed agricultural water used in the Great Valley of California, there was grave concern and

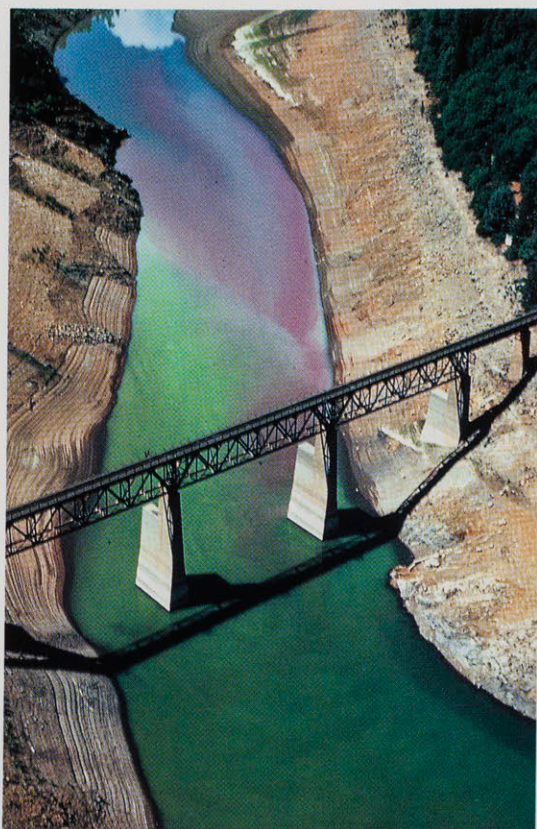


Map showing the route of the Little Sacramento River through the Sacramento River Canyon and the site of the Cantara Loop Spill.

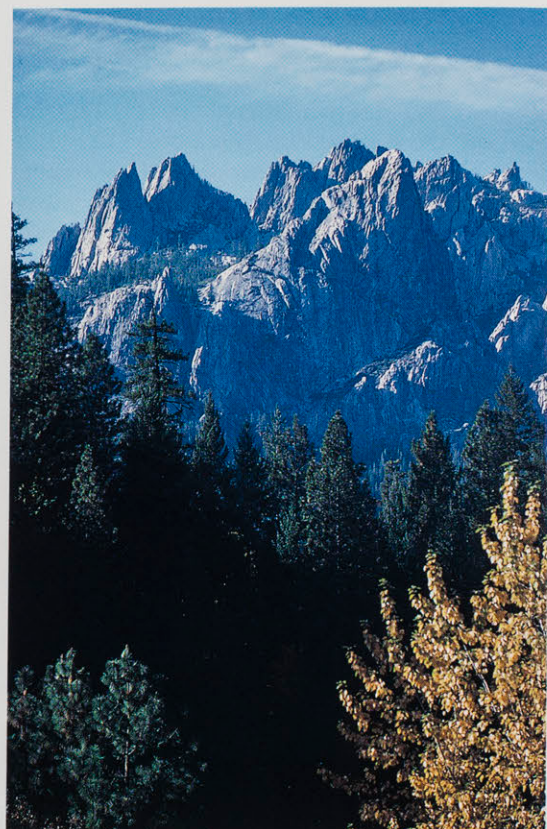
The attenuated toxic plume from the spill advances down the Sacramento arm of Shasta Lake, under a rail bridge near Lakehead. A purple dye was added to the leading edge of the plume to make tracking and monitoring easier. The plume began to sink after it hit the Shasta Lake thermocline.

RIGHT

Castle Crag, 6,500 feet of granitic boulders, are seen from Soda Creek. Legend has it that a fortune in gold dust, hidden by the Indians during their 1855 battle with early settlers and miners, is still hidden somewhere among these rocks.



California Department of Fish and Game



E.G. Barham

uncertainty. Not only at risk were the reservoir's living resources, but there was the dire threat of the toxins passing through that system and into the outflowing Big Sacramento. The City of Redding (population over 70,000) and other downriver communities were dependent on river water for domestic use and crop irrigation. The Blob also represented a threat to the winter-run Chinook salmon, an endangered species whose population had diminished from thousands before the construction of Shasta Dam to about 200 returning ripe fish. Their critical annual production of fingerlings were just emerging from the gravel.

News of the spill, and regular updates on the movement of the Green Blob, hit the nation's headlines and television screens. The story was the hottest to emerge from these hinterlands — a locale best known to the national news media as a place where old pickup trucks come to die — since the eruption of Mt. Lassen in 1914.

From Dunsmuir to Red Bluff, citizen reaction intensified from concern to outrage. Sacramento V.I.P.s and public agency leaders helicoptered over the advancing toxic plume like an agitated swarm of giant dragonflies.

Almost three days after the spill, the plume reached Lakehead, the uppermost extension of the giant Shasta Reservoir. Following more than five years of drought and Bureau of Reclamation

drawdowns, the water was at an historic low and the arm was still essentially a slow-moving river narrowly confined within the raw, red-soil ditch of the Little Sacramento's old river bed. As the plume crept on, it eventually commingled with the reservoir's huge pool of static water. Three fortunate things then happened: one, the form of the green blob contracted, the trailing portion catching up with the sluggish front; two, its toxicity was diluted; and three, the virulent mix, being heavier than the reservoir's warm surface waters, sank to a depth of about 20 feet, where it was suspended on the summer thermocline. This is a narrow zone of sharply decreasing temperature present in deep impoundments, which effectively separates the reservoir's waters into two strata: a warm, mixed upper zone and a much greater volume of cold, heavy bottom water. Because its specific gravity was about equal to the density of the thermocline, the Blob was suspended in mid-water rather than settling and sterilizing vast areas of the reservoir's bottom fauna of macro invertebrates — important components of the food chain.

For the next two days, the submerged Blob crept on, resulting in a major kill of phytoplankton and zooplankton. Adult cruising fish, however, seemed to easily avoid the slow-moving toxic concentration.

AT A PUBLIC HEARING IN REDDING, some 400 heavy-breathing people jammed into a motel conference hall and listened to Southern Pacific spokespersons offer an apology and cite lax Federal regulations and an incredible run of bad luck for the disaster. Outside the crowded room, a small group of dissidents beat on conga drums and agitated for action.

Meanwhile, unbeknownst to the public, a hastily formed consortium of Southern Pacific managers and representatives of some 35 public safety and environmental protection agencies was brainstorming around the clock on possible strategies to break down and dissipate the toxic concentration. Almost a week after the spill, a team of hazardous material specialists mustered by Southern Pacific were ready to attempt a novel, untried approach.

The attack began. Four fire engine pumpers lashed down on barges were tethered to the shoreline and held over the plume. Air was piped to the toxic mess to oxidize it. Because officials feared atmospheric contamination, water was sprayed over the operational area to absorb possible airborne toxins.

After a week of oxidizing, MITC levels were reduced from about 35,000 parts per billion to near undetectable levels. On July 30 1991, two weeks after the spill, the emergency was officially declared at an end.

PRELIMINARY OBSERVATIONS OF DAMAGE

Few things in nature are as gut-wrenching as a poisoned river. Only the aftermath of a forest fire is more shocking to the senses. But there, at least the bodies are charred beyond recognition so that one does not relate them to the living form.

On one mid-July day a few days after the disaster, the dead trout lying at the foot of a sparkling spring gushing from a sheer hillside near Conant looked as if they had been preserved in grain alcohol. Their bodies were unmarked, every fin ray intact. The only signs of death were their stillness and the faded brilliance of their crimson-colored lateral lines and gill covers, the iridescent color that over a hundred years ago inspired David Starr Jordan, the pioneering ichthyologist who became the first president of Stanford University, to name this species "rainbow" trout. They had died quickly, if not without terror and pain. Still partially buoyant with gas in their swim bladders, the trout lay on their sides at the river's edge, lodged between boulders and rocks. Occasionally, a body worked free and drifted downstream.

Far more numerous were the small car-

casses of other native fishes. Littered among the boulders at the foot of the spring-fed riffle were the white, belly-up bodies of sculpins and diminutive speckled dace. Mixed with these were the smaller, dark-blotched bodies of fingerling trout.

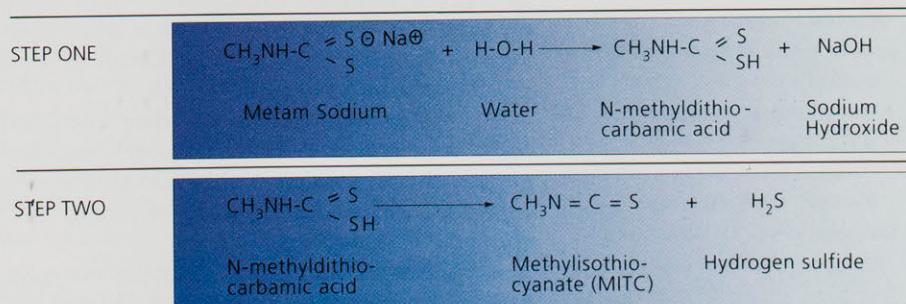
Turned rocks exposed pockets of dead insect larvae, mainly stonefly nymphs. A few worm-like caddis fly larvae hung limply, half out of their pebbly cases. Tucked in crannies were the decomposing remains of soft-bodied worms of various types. Dead, opaque snail eggs, still encapsulated within their protective gelatinous masses, adhered to the undersides of rocks. The shells of adult gastropods were scattered in the gravel along with the closely related limpets. A short search up and down stream revealed the remains of crawfish and newts. The spill's timing was devastating for those amphibians who return briefly to the river to mate and lay eggs.

Macroinvertebrates, the primary food source for fishes, were essentially wiped out by the toxic purge. It would take a small tome on aquatic biology to list the casualties by species. While the organisms grab one's attention, they represent the upper tiers of the food chain pyramid. The aquatic and terrestrial green plants, which fix carbon through the photosynthetic process, are the all-important primary producers of the ecosystem, and the essence of its productivity.

A distinctive attribute of the Little Sacramento is its riparian, the lush border of deciduous trees and brush understory that lines its shores. On that day at the Conant riffle, the filamentous green algae and the epibenthic moss-like growth of algae, fungi, stalked diatoms, and associated protozoans, collectively known as periphyton, were bleached white, slimy, and apparently dead. Obvious signs of gross damage to streamside vegetation were varied. Dark green clumps of Indian rhubarb clung to streamside rock ledges with fleshy roots. Their huge, elephant ear-shaped leaves, held aloft like an array of miniature umbrellas, showed scattered leaf burns (see illustration, page 33). The willows,

Reactions of metam sodium to form the primary toxins involved in the Cantara Loop spill: Methylisothiocyanate (MITC), hydrogen sulfide, and sodium hydroxide. Modified from the California Department of Fish and Game's Damage Assessment Plan, this drawing shows the pathway of the sodium molecule's combination with the hydroxyl radical of water to form sodium hydroxide (caustic soda).

First Phase Reactions of Metam Sodium in Water





An upstream view of the Little Sacramento River from Sweetbriar, with Castle Crags in the far background. The "killing pool," where neighborhood children tried vainly to save a huge, stricken trout, is just downstream.

growing on gravel bars with their pink root-clusters in water, also exhibited necrotic foliage. Conversely, the major components of riparian growth — alders, ash, cottonwoods, maples, and their understory, dominated by huge, sprawling blackberry bushes and horsetails — seemed unharmed.

Trailing behind the plume at what was considered a safe time-lag, prison laborers, wearing protective garb, worked with California Department of Fish and Game (DFG) personnel to sack up about 100,000 fish carcasses. The dead fish were collected from eight randomly selected sections.

DFG was also concerned about terrestrial predators, particularly ospreys, bald eagles (an endangered species) king fishers, water ouzels, mergansers, and others that are entirely dependent on riverine organisms for prey. While some of these birds might find new territory in the major Little Sacramento tributaries and other nearby rivers, they would overload the carrying capacity of those habitats.

A pair of nesting ospreys were of particular concern, and DFG employees provided hatchery trout held in large river enclosures as easy pickings for the adult birds until the fledglings were capable of leaving the nest.

Mammals, such as the river otters and mink, with restricted ability to cover long overground distances, either died or relocated in river tributaries and in the few miles of healthy river above the Cantara loop.

But these are only high-graded examples. Loss of the river food chain and the widespread

toxic cloud affected, to some degree, all living things in the canyon.

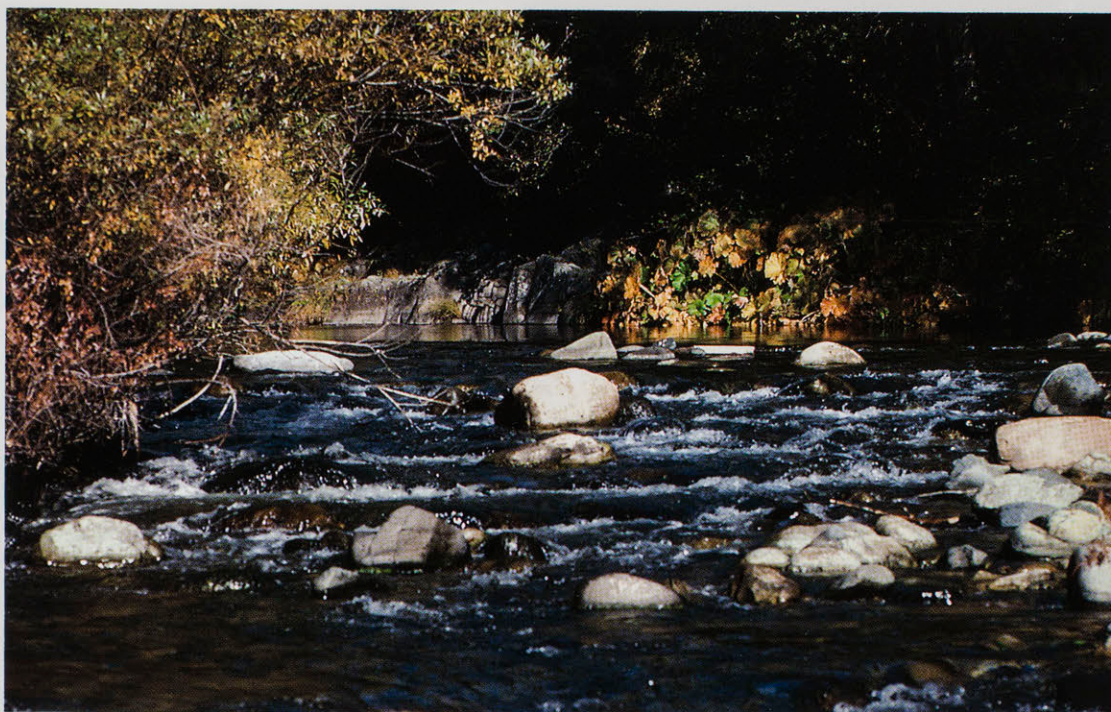
Yet "dead river," a term frequently used to describe the Little Sacramento in the days following the spill, was an overstatement. Like wartime massacres, where a few badly wounded soldiers crawl off into the brush and live to tell the tale, some aquatic organisms survived the chemical purge. On the fifth day after the spill, the author returned to the Conant riffle site with San Francisco's mobile KRON-TV news crew, the station's science reporter, Dr. Tom Linden, and Tom Hessel-denz, Region One director for California Trout, a wild trout advocacy group. At a place where a seep trickled into the river, apparently creating a small sanctuary of uncontaminated water, Tom Hessel-denz pointed out three tiny, almost transparent trout fingerlings, quite alive and flitting nervously about their small zone of safety. The author took this as a good omen for the future.

Certainly, we thought, there must have been many such back-water niches where life endured. And the unhatched eggs of insects, sealed in their impervious chitinous shells, as well as those forms that burrow into the substrate, may also have escaped annihilation.

FIRST PHASE ECOLOGICAL RECOVERY

Historically, healthy lotic ecosystems recover from massive toxic impacts. After all, a flowing body of water, unaffected at its sources, is self-purging. The system's physical and chemical parameters are temperature, transparency (which governs light penetration), and dissolved oxygen (a function of temperature, ratio of surface area to volume, and mixing). Further, mineral content and related Ph interact to create a culture medium that needs only inoculation to again support the interacting assemblage of plants and animals that form a self-sustaining, trophic pyramid of life. In turn, the metabolic processes of the flora and fauna modify the aquatic environment into its original character.

Fortunately, the Little Sacramento has several factors in its favor. The stream escaped the worst of the hydraulic and dredge mining era, whose devastation is observable to this day in the riparian of some other nearby rivers. The perennial spring spate flushes the gravel clean, and there are no major diversions of the Little Sacramento's water. Most importantly, the railroad right-of-way has protected the stream against the sort of massive hydroelectric development that converts a free-flowing, wild river into a series of tame reservoirs, at best connected by short sections of productive



E.G. Barham

At the head of the Conant riffle, the willows in the left foreground and the cross-stream clump of Indian rhubarb were affected by the toxic tide. This picture, taken four months after the spill, shows that even though their leaves were turning to autumn color, the plants showed marked recovery. The small, bright green leaves of the rhubarb regenerated after the spill.

tail-water and longer reaches of degraded habitat — the fate of the adjacent Pit River. Since 1966, about half of the McCloud River has been diverted to the hydroelectric generators of the Pit; in 1963, more than half of the Trinity was turned around and tunnelled to the Carr Power House at Whiskeytown and on to the hydros of Shasta Dam. The lucky Little Sacramento escaped all that.

The stream's major tributaries and the stretch of unimpacted water above the Cantara Loop should function as biological reservoirs to populate the relatively lifeless river. The importance of these colonization sources to recovery of the impacted ecosystem cannot be overemphasized. It would be better yet if Box Canyon Dam were not

there; then nearly a hundred miles of the headwater drainage system would be a major source of replenishment. Fortunately, the heat of the summer of 1991 continued unabated well into November, maintaining the metabolic rates of cold-blooded animals and extending the growing season.

Theory is fine, but the author wanted to see how things were working. At monthly intervals, he visited familiar river locales such as the WPA Bridge at Sims. There, on October 9, 1991, just at dusk, so many dipterous insects were emerging through the surface film in the low light that they looked like raindrops hitting the water. These were probably blackflies, closely related to mosquitoes. Dipterous forms have a very short life cycle; this species could easily have gone through several generations since the spill. What appeared to be a small trout was rising steadily at midstream.

More reassuring, indications of ecological recovery were obvious about a month later on November 7. Moss-like periphyton mats and long, filamentous green algae were growing lushly over shallow river cobble. It was almost as if these plants had been fertilized. And wonders be, a swarm of small mayflies, genus *Baetis*, was performing its midair mating dance at the edge of the stream. Stones turned at the foot of a riffle revealed many gravelly caddis pupal cases glued to their undersides. It was like finding biological flakes of gold: both types of insects are important fodder for predaceous fishes.

That same day, a few miles upstream, the willow and Indian rhubarb that had shown spill-



California Department of Fish and Game

Four days following the spill, fish carcasses were found massed together in a backwater. At this downriver site, the fish fauna is different from the upstream's prime salmonid and riffle sculpin population. Two wild rainbow trout (touching each other at lower left and center) are flanked by native nongame fishes: the large fish is a giant minnow, the Sacramento squawfish, and the other three are Sacramento suckers. The rainbow trout at lower left is probably nine or ten inches long.

related damage were not only alive but now exhibiting marked recovery. Metam sodium is a herbicide, a serious threat to the flora within the river corridor. Unfortunately, we cannot extrapolate from the encouraging signs of lush growth exhibited by submerged aquatic plants — such as algae and periphyton, to a similar state of health for the nearby terrestrial plants that take up water through root hairs and transport it to their leaves via a vascular system. However, the willows and Indian rhubarb, with their roots awash in the water, would seem to have been index species for gauging terrestrial plant damage. If they survived, as they seemed to be doing, then we might expect that the major components of the riparian zone — the alders, cottonwoods, maples, azaleas, and understory growth would also escape lethal damage.

The status of the primary riparian trees is of great importance to the timely recovery of the river. This arbor-like stand of bordering plant growth provides shade, is habitat for terrestrial and emergent aquatic insects, and acts as a filter to trap erosion of the flood plain; the tree's root clusters help form lateral scour pools that create holding water for trout.

The riparian serves one other important function. In the heavily fished reaches of the Little Sacramento, the sprawling blackberry understory, with its cruelly thorned canes, bars access to anglers on long stretches of the river and thus provides sanctuaries for trout. In brief, if the riparian is intact, then much of the habitat is intact and receptive to rapid ecological recovery. This is exactly what appeared to be taking place. Clearly, the river's wounds were healing.

For those who experienced the event, the Cantara Spill and its impacts were a devastating experience. Perhaps most shocking to the human psyche was the sudden and almost total annihilation of a river ecosystem: one moment feeding trout dimpled the surface, water striders skated on the surface film, and the ouzel flitted to its favorite caddis case-covered rock and bobbed a greeting. Then there was death and belly-up fish and only the motion and sound of running water.

That's not the way to kill a river. We are used to having it done slowly and in the name of progress: high dams and huge hydroelectric power plants; mine slag and timber slash in the headwaters; massive flushes of human and industrial wastes; and there are many more — let us count the ways.

A biological oceanographer known for his deepsea submersible studies, Dr. Eric G. Barham is retired and lives in Redding, California. His account of the Cantara spill reflects a merging of his professional background with ecological interests.

Epilogue

HOW LONG WILL IT TAKE the Little Sacramento River to recover? To answer that, we must define what the river was before the tragedy, attempt to measure the losses, and agree to criteria for recovery. Further, this must be done within the context of federal and state laws, which in the end will demand compensation from the entities held responsible for the effects of the event.

The Federal laws affecting the situation are the so-called Superfund Act and the Clean Water Act. Since the spill, Department of the Interior agencies (Fish and Wildlife Service, Forest Service, Bureau of Reclamation) have worked with California's Department of Fish and Game (DFG), the lead agency responsible for rehabilitation of the river. Because DFG must comply with federal procedures in documenting resource damages and establishing compensation, much of its initial report on the catastrophe was written by time-constrained staff lawyers and desk-bound managers rather than by field biologists.

The legal dicta demand that (1) the nature and degree of toxin impacts on all living components of the river and its immediate environment be determined and quantified; (2) time for both natural and man-aided recovery be estimated; (3) compensation be calculated for user loss of resources. In response to these requirements, the DFG's plan lists 352 species of plants and animals as potentially impacted. This figure doesn't include aquatic

plants and invertebrates, the two most important and vulnerable trophic levels of the river's food chain. To accomplish the critical first objective, the DFG defines 38 tasks having to do with methodology, technique, and personnel. The projected cost of completing these tasks is about \$10 million; the time estimated to carry them out ranges from four months to 10 years.

The purpose of this work is to establish baseline data for assessing the full extent of damage; compensation will come later. Baseline status will be extremely difficult, if not impossible, to determine in many cases — for example, in assessing pre-spill populations of large stoneflies and sculpin, both important forage for wild trout.

Since pre-railroad days the majority of users of the Little Sacramento have been recreational anglers. Therefore, the nature of that fishery as it existed before the spill is vitally important as an index of recovery. Throughout the report, there are brief mentions of the stream as a "blue ribbon" or "gold medal" trophy wild trout fishery. Before the erection of Shasta Dam, that may have been true, but in the past 35 years, the DFG has planted at least 1.5 million catchable-size, hatchery-raised trout in the upper sections of the river. These fish constitute the vast majority of trout taken by any method, whether bait, fly, or lure. The fisheries of the lower river, from about Shot Gun Creek to Lakehead, are different and are strongly influenced by migrations of both native and intro-

duced species from Shasta Reservoir.

Following the spill, the DFG put into effect interim regulations outlawing all fishing in the main stream and unaffected tributaries and in Box Canyon headwaters. DFG then produced a recovery strategy plan that would allow the wild strain of native rainbow trout to repopulate along with a balanced, supportive ecosystem — without negative impacts from introduced hatchery fish. To achieve this, a hands-off period of at least two years was recommended. A total ban on fishing and suction dredge gold mining within the drainage went into effect in March of 1991. The plan also called for introducing fingerlings raised from wild trout progeny in special "natural" hatchery ponds.

DFG's "go slow" recovery plan was strongly opposed by some user groups. To a large and vocal number of citizens, evidence of stream restoration meant not so much a return to natural ecological balance that provides for a diverse native ichthyofauna, but rather "good trout fishing." To Dunsmuir business owners who relied heavily on trout fishers' dollars, that could have been achieved within a month of the spill, simply by sluicing in a few hundred pounds of DFG's hatchery product along the Dunsmuir stretch of the river. A two year (or longer) period of fishless days seemed like insult added to injury. (If the criterion for full recovery is a river full of robust wild trout, the wait will be much longer; Little Sacra-

mento rainbows are slow growers.)

Even California Trout, an organization that has long advocated self-sustaining wild trout populations, was negative about some aspects of the DFG's plan. California Trout joined forces with Southern Pacific Transportation Corporation to formulate a separate plan for the first year of recovery. They recommended that a far greater number of wild fish from the unaffected tributaries and Box Canyon be stripped of their eggs and sperm for modified hatchery culture.

As yet, DFG has not issued a written commitment of its recovery objective. Scientific knowledge of the ecological parameters is incomplete, and the paradigms necessary to understand the response and recovery of riverine environments to negative impacts are still being developed. Almost all of the existing models are based on east coast, warm-water streams, and it is uncertain whether we can safely extrapolate from these types of rivers to western, freestone trout streams. DFG will have to consider a management philosophy that can both enhance the resource and equitably serve the diverse interests of fishing license holders. Its "go slow" strategy should be applauded as an exemplary management policy that gives long-term welfare priority over short-term economic gain.

Modest Fortunes

MINING IN BAJA CALIFORNIA

by Donald Chaput, William Mason, and David Zárate Loperena

The Natural History Museum is now publisher of the Baja California Travels Series, a series of books presenting accounts of travel and exploration in Baja California. The series was initiated in 1965 by Glen Dawson of Dawson's Book Shop in Los Angeles and Edwin H. Carpenter of the Huntington Library in San Marino; to date, it includes 51 titles. The Natural History Museum assumed publication in 1989, a move that reflects the History Division's strong collections and research interest in the area.

Following are excerpts adapted from the 51st title of the series, *Modest Fortunes: The Mines of Baja California*, written by museum History Curators Emeritus Donald Chaput and William Mason, and David Zárate Loperena, Professor of History at the University of Baja California. *Modest Fortunes* was released by the museum in the fall of 1992.

THE HISTORY, NATURAL SETTING, and current circumstances of Baja California remain remote to all but a few travelers and armchair sojourners. As that small band knows, the redoubtable terrain of this land has dominated all aspects of human habitation. Not even the insider, however, is likely to be very familiar with the region's mining history, since that is one subject largely neglected in Baja California literature.

Mining in the peninsula was characterized by countless thousands of small claims and operations, the vast majority of which were unsuccessful or short lived. Only a handful of large-scale mining operations were ever established. Neverthe-

less, the many small mining attempts had a great impact on this sparsely populated and largely unknown land. Towns were established as a result of mining efforts, and remote and inhospitable areas were explored and surveyed.

The area of concern of *Modest Fortunes* is the state of Baja California, which comprises the half of the peninsula that lies north of 28 degrees latitude. Although mining was important throughout the entire peninsula, the financing, working methods, and transportation links in the north differed considerably from those in Baja California Sur. The mines of the south, such as the silver mines at El Triunfo and the salt deposits on Isla de Carmen, were generally Mexican ventures for Mexican markets (with the notable exception of the copper center of El Boleo at Santa Rosalia, which was an exclusively French operation). Mining operations in the northern half of the peninsula were closely connected to the economic and political life of San Diego, Los Angeles, and San Francisco because of the region's geographic proximity and coastal access.

Information about the mining history of the peninsula has been drawn from sources in libraries and archives of Mexico, the United States, and England. Although it is obvious that government reports and mining studies could be found in Ensenada, La Paz, Tijuana, and Mexico City, it might be less obvious that San Diego, Los Angeles, San Francisco, Tucson, and London have collections of letters, diaries, and books that shed considerable light on mining in Baja California.

Though newspaper clippings and land records might be obvious sources of information, other intelligence comes from unexpected areas. The American Smelting and Refining Company of Tucson, for example, retains important geological studies of copper and gold properties. The Guildhall Library in London holds the papers, diaries, and letters of Sir Buchanan Scott, the Ensenada manager of the Mexican Land and Colonization Company.

On the little ride of a mile or two while making the circuit of the ponds, we found rattlesnakes rather too common to please nervous people. We killed three in the trail, in an hour. — J. Ross Browne, A Sketch of the Settlement and Exploration of Lower California (San Francisco: H.H. Bancroft and Company, 1869, 110)

The aim of *Modest Fortunes* is to put before the reader information on the mining history of northern Baja California from sources that either have not been used previously by researchers or writers or have been used only rarely. The selections are taken from manuscripts, hard-to-find newspapers, obscure journals and pamphlets, mining claims and titles, and United States and Mexican corporate sources. They provide a sampling of the kind of geographical, geological, and mining infor-

mation that was available in previous centuries. The book presents diverse views, including a Jesuit ridicule of mineral riches, London entrepreneurs' praise of the new gold fields, San Diego's report on its efforts to annex the peninsula to the United States, and accounts of the determined efforts by miners/investors Emiliano Ibarra, David Goldbaum, and Eulogio Romero to make the mines pay, and to open the country in the process. The sometimes futile search for mineral wealth figured largely in the region's history, for the mining and milling efforts that brought roads, ports, and new settlements to the northern half of the peninsula changed life there forever.

Baja California was a challenging environment in the late 19th century, and these accounts indicate how important were considerations of climate, knowledge of the land, and tenacity.

THE Cucapá placers of northeastern Baja California include hundreds of pockets of gold located in the foothills and mountains of the Sierra de los Cucapás and in the adjacent deserts. Placers are deposits of gold particles found in loose surface material transported to a site by erosion or flood. Such deposits are easily worked, but they are soon exhausted. "Cucapá country" was a vaguely defined region, but there was no question about the connotation of the phrase. An article on gold prospecting in the *San Francisco Examiner* opened with the sentence: "God may have wrought a place more terrible than the Cocopah desert of Lower California,

The search for metals and other resources took place in many regions without roads or trails. Prospectors, miners, and surveyors penetrated many virgin areas and often provided the first specific knowledge of vegetation, geology, and animals.



San Diego Historical Society Photo Collection

but if so it is unmarked by the trail of mortal." The difficult terrain and inhospitable climate presented a formidable challenge for even seasoned prospectors.

The Cucapá Indians were fully aware of the value of gold and of the benefits of keeping a lid on the location of the best placers. The following accounts of outsiders' attempts to unravel the Cucapás' secret tell a vivid tale of the physical hardships facing prospectors.

From the *San Diego Union*, November 14, 1873

THE COCOPAH COUNTRY

It is a well known fact that the Cocopah Indians, whose dominion lies west of the Colorado river, near its mouth, do not like to have white people enter their country . . . It is also a well known fact that the Cocopahs buy all they need with gold nuggets. A story is told by one of our citizens who was well acquainted with the hero. A negro became acquainted with the Cocopahs in 1862, and soon became a great favorite of them. He finally asked and was granted permission to penetrate their country to a place where they said gold could be picked up in large quantities. He returned with a large amount of gold nuggets, but with the warning that he must never take anyone back with him. He disobeyed the warning, and with a companion and two pack mules went back into the mountains. Neither he nor his companion have been heard from since.

From the *Mining & Scientific Press*, November 29, 1873

THE LOWER CALIFORNIA PLACER MINES

The Cocopahs inhabit a mountain range in Lower California, which looks down on the Colorado Desert, and extends for a great distance down the Peninsula. Their territory runs on to the Desert. They have always guarded it jealously. When the Messrs. James and Purdy conducted an expedition to the mouth of the Colorado, at the instance of Mr. Chapman and others, with the ostensible view of discovering the practicability of making the Colorado Desert a salt water lake, with the benevolent object of modifying

the climate, they encountered the Cocopahs in force. The chief, Myore, utterly forbade their passage through his dominions. After much entreaty he finally consented to allow them to pass, on the condition that they should put up their surveying implements and make no observations. They thus effected a hurried passage to the mouth of the Colorado.

The Cocopahs are a fine, martial race of Indians, and, as near as can be ascertained, there are between two and three thousand of them. They are tall and use the primitive bow and arrow as weapons. Breech clouts and certain rustic ornaments, with blankets, make up their equipment and apparel. They are brave and good humored, but resent any attempt to penetrate their country.

It has long been known that the Cocopahs have had access to gold. In the old days, and at intervals up to date, they have been in the habit of going to Yuma and paying for their goods with dust and chunks of gold. In the time when Hinton used to keep store at Yuma, parties of Indians were wont to make their way to his place and barter gold for goods. He frequently endeavored to find out where they got the gold, but ineffectually. Their habit was, also, to ornament themselves with rare gems of virgin gold. . . .

The fact that the Mexican Government is beginning to turn its attention to Lower California is shown by the detailing [of] Señor Blanco to make a prolonged reconnaissance of the Frontera, which was done in the latter part of last winter . . . If the statement made by Peters is true, that he prospected in the Cocopah mountains fifty or sixty miles from Japa, and that he found very rich placers in the mountains, as well as running water and abundant wood, why, then, taken in connection with the removal of the Cocopahs, and putting them on a reservation, we are going to have lively times and a new era of development in Lower California, and an unprecedented activity in San Diego.

From the *Lower Californian* (Ensenada), July 24, 1890

THE CUCAPA PLACERS ARE EVIDENTLY EXTENSIVE AND WORTH INVESTIGATING

An Indian came in last Saturday from the Cucapa country with fourteen ounces of gold dust for Mr. F. B. de la Pina, one of the concessionaires of the rich mining district in the Cucapa mountains, where the gold was found. The Indian also brought a message from Victor Tapia, the manager of the property, who states that the district is proving itself to be very rich, especially in placers, which are very extensive. . . . The Cucapa placers are from one to two feet above bed-rock.

THE FACT THAT ONE HAS AN original or solid source does not mean that interpreting history is easy. The El Fenómeno tungsten mine at Rosa de Castilla, about an hour's drive south of San Diego, illustrates this point well. The production of

The El Alamo gold fields were closed and re-opened numerous times. Hilly terrain, unpredictable streams, and roads more like pathways were routine obstacles for drivers attempting to bring mining equipment to this region 30 miles inland from the Pacific. The driver in this picture, taken in the late 1920s, was from Ensenada, the truck from Detroit, and the boiler lashed onto its bed was from San Francisco.



Zarate Family Archives

tungsten, used to produce very hard alloys of steel, was increased considerably during World War II. Over a hundred people lived at the El Fenómeno site where, in addition to mills and other processing plants, the operators also opened a school and hospital.

Tungsten production came to a halt in 1944. Engineer Henri Jacot explained the reason to officials of the American Smelting & Refining Company, which was considering buying El Fenómeno:

The mine was rich, the price of tungsten high; Mr. Horton was making much money; the business was "too good." Labor trouble started and went from bad to worse until Mr. Horton angered by the excessive demands of the leaders and the ingratitude of the men he had liberally treated with true kindness, gave up the game and quit.

In 1945, however, a U. S. Geological Survey report concluded that the collapse of the tungsten venture was for other reasons:

Despite the stimulus created by the well-operated El Fenómeno mill, no deposit deemed rich enough or large enough to be mined commercially was found, and in August, therefore, all exploratory work by the El Fenómeno company was halted.

Here we have two first-hand, primary sources discussing the collapse of tungsten mining, and they seem to contradict each other. Yet perhaps both views were correct. It could have been that labor troubles erupted just as Horton decided to bow out because geological studies had indicated that the richness of the ore was declining.

Historians have mixed feelings about the usefulness of newspapers as source material. They are often carelessly edited, printing rumors as fact and giving confusing or incorrect accounts of places, people, and events. Small-town papers are also notoriously guilty of local boosterism, which frequently obscures the truth. There are times, however, when newspapers contain the only information about certain events or personalities. And, in some situations, the differing opinions of several newspapers can help in understanding conflicting data. A few newspapers, such as the Ensenada *Lower Californian*, had a relatively long life (1887-1899), yet copies are rare and have seldom been used by researchers. For other newspapers, such as the *Alamo Nugget*, no issue has survived, and the content of the paper is known only through occasional columns that appeared in newspapers in San Diego or Los Angeles.

Following are two types of accounts, one from a newspaper presenting mining insights along with a bit of humor, and the other by a prominent scientist, Edward Nelson, who while in the field had to deal with such routine matters as obtaining food, water, and directions.



Zarate Family Archives

David Goldbaum, born in western Mexico in 1858, was an Ensenada pioneer. His career there stretched from 1888 until his death in 1930. Goldbaum was a surveyor, cartographer, miner, government seed inspector, and mayor of Ensenada. He began mining at the El Alamo gold fields in 1889, and was involved in mining the rest of his life. He is shown here at El Alamo in the 1920s, sifting streambed gravel with a device known as a "rocker" or "cradle."

From the *Lower Californian*, August 14, 1891

Colonel Lane and J.M. Gonzalez, accompanied by Philip Crosthwaite, Sr., have returned from a trip to the latter's ranch at San Miguel, twenty miles north of town, where they went to examine an old silver mine. The mine has not been worked for about thirty years. It was first opened by the Padres of the Mission of San Miguel, but was abandoned by them when their lands were confiscated by the Government a good many years ago. A Frenchman named Bonet reopened the mine about 1860 and worked it three years, when he also abandoned it. According to tradition, Bonet considered the mine very valuable and made many attempts to interest men of capital in the property, but his efforts were ineffectual because of his dissolute habits.

Messrs. Lane and Gonzalez examined the mine as much as possible and brought back with them some ore from the old dump, which they will have assayed. It was impossible to descend into the shaft, which is said to be sixty feet deep, because of the great swarms of bees which flew in and out. A little development would doubtless disclose an immense amount of honey if nothing else, and of the best kind, too, for the land about the mine is thickly covered with white sage. But Messrs. Lane and Gonzalez are not after honey — it's silver they want, and if later examinations prove the mine to be worth anything they may develop it.

From Edward W. Nelson, *Lower California and its Natural Resources*, 1922

Practically throughout this expedition our stock was forced to depend for food on the plants growing on the desert, and edible species were often extremely scarce. By the time we reached San Francisquito the animals were so worn down we were obliged to rest several days. It was extremely hot here, and in order to save the stock as much as possible we broke camp September 13 at 4 a.m. in brilliant moonlight and traveled 10 miles easterly, following the wagon road from the water canyon across the plain and down a low-walled canyon leading toward the gulf, to the King Richard mine. This is a gold mine worked by an Englishman named Dick Daggett. To our surprise the camp was deserted, every house was locked, and there were no signs of recent occupation. This left us in a serious position, for we had less than a pound of flour and no beans, rice, sugar, or bacon, and were many days' travel from any supply point. We had seen Daggett several weeks before at San Quintin, and he had agreed to sell us provisions, if needed, and it became necessary to find him or face a trip of several hundred miles to the next supply point, subsisting on such small game as we might shoot. Several used trails radiated in various directions from the camp, one leading down the canyon toward the gulf showing the most recent tracks. We followed this for about 6 miles, through a series of small canyons and over dividing ridges in a broken granitic and slate hill country and came out into the broad, gently sloping Calamahue Valley, through which a dry rocky wash, like a broad river bed, wound its way. The trail led us thence down the valley about 9 miles to the mouth of the wash, where it passes through a narrow gap between two low ridges of hills and reaches the gulf at a point on the shore known as Calamahue Landing. This is one of several places along the gulf coast where supplies ordered from Guaymas, Sonora, are occasionally landed for mining companies. We were much relieved to find a group of small brush huts by a shallow well at the base of the hill on the right of the gap, where Daggett and his miners were camped. Daggett welcomed us

hospitably and said that through a misunderstanding his supplies failed to arrive on time from Guaymas and he and his men were forced to close the mine, come down to this point, and subsist for more than a month solely on sea turtle and fish caught in the gulf. Fortunately for us the night before our arrival the boat had come in and the supplies were lying on the open beach at the mouth of the wash. Daggett told me that he and his Indian miners had been living for two weeks on fish they managed to catch along shore and wild honey from the rocky hillsides.

Daggett kindly sold us the necessary provisions, and we turned back up the valley about 3 miles and made a dry camp. The day was extremely hot, and as we traveled up the smooth sandy flat, just after sunset, we saw two "side-winder" rattlesnakes lying in the warm dust of the trail. On our approach they slid diagonally sidewise and forward about 15 feet to one side of the trail. There they stopped and sounded their low warning rattles as each animal of our outfit passed.

There was scarcely a shred of feed either at Daggett's, or where we camped, and for salvation of our animals it was necessary to find pasturage. . . .

We remained two days at Calamahue to rest the animals. It was excessively hot and each day a strong wind blew down the canyon which seemed to come directly from a furnace. Guns or other iron objects left for a short time in the sun became too hot to handle. The intense heat, high winds, and bad water at this place made it such an unpleasant camp that on September 16 we were glad to move on.

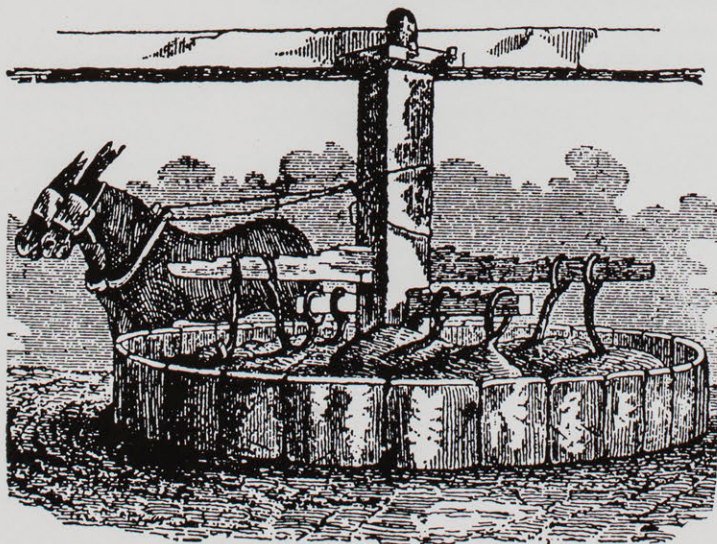
EXPLORING IN SMALL CRAFT along the Gulf of California coast, riding astride a donkey through the Sierra de Juárez chain, or trying to find an obscure trail through the sands of Laguna Salada were hazardous ways of trying to find deposits of ore. Extreme heat or cold, scarcity of water, and absence of settlement or aid of any kind led to hardships, sometimes death. The following accounts indicate the dedication — or foolhardiness — of many of the prospectors and miners.

From the *Lower Californian*, July 22, 1892

LOST ON THE DESERT

Another story of probable death on the desert comes from San Diego. On the 4th of June, S.I. Breedlove and his son, C. Breedlove, and a capitalist from the East of the name of Fish left that city on a trip to the Cocopah region of Lower California in search of gold. After they had been gone several weeks and nothing had been heard from them, the fear arose in the minds of their friends that possibly misfortune had overtaken the men on the desert, and a relief party was organized to go in search of them. After leaving Campo and getting into the desolate country to the eastward the searchers came upon the wagon belonging to the prospectors and in which was found a large part of the

The *arrastra* was a Mexican milling device that spread throughout all of North America. Animals walking in circles pulled heavy stones over ore-bearing rocks. After the material had been finely crushed, it was treated with mercury, which combined with the gold into an amalgam that was easily recovered. From *The Hand-Book To Arizona*, 1878.



provisions which Breedlove and his partners had taken with them. No signs of the men or of the direction in which they went after abandoning the wagon were found, but the mules belonging to the men were traced to a spring some distance away where they had evidently remained some days, although they had gone before the searchers arrived. The relief party, unable to find any trace of the men, was compelled to return to San Diego. Another party has been organized to make a more thorough search, and two brothers of Mr. Fish are en route from the East to join it. The Cocopah country offers hardships enough to the prospector even in winter, but to undertake a journey thither at this time of year is a proceeding that none but the most reckless would ever dream of. True, it had been done, but in each of the few cases with such suffering to the adventurers that all the gold of Ophir would not induce them to make the trip again in the summer months. Brown and Crawford, who understand the Cocopah country better than any other men that we know of, say that one day in that region without water during the summer months is sufficient to cause a man to lose his mind. It is well for prospectors to remember the fate of young Mr. Singletary and other men who have suffered death from thirst on the desert surrounding the Cocopah mountains.

From the *Lower Californian*, July 29, 1892

Since our last issue the bodies of the elder Breedlove and the capitalist Fish have been found on the Cocopah desert, one hundred miles northeast of Ensenada, where thirst had overtaken the men and they had fallen down to die. The searchers followed the trail of the two men and came first upon the body of Fish lying on a blanket. From there Mr. Breedlove's tracks led some distance further on and evidence was plain that he had repeatedly fallen to the sand, only to struggle on each time in the search for water to save his life and that of his friend who was unable to go on. Mr. Breedlove's body when found was lying face downward and his hand was outstretched toward his canteen, which apparently had fallen from his shoulder. The younger Breedlove, who was one of the ill-fated party, has not yet been seen, and it is not known whether he found water or wandered off to die a horrible death like the others. The two bodies found will be taken to San Diego in metallic caskets.

EMILIANO IBARRA [YBARRA] was one of the most important figures in Baja California mining. He was born in Choix, Sinaloa, in about 1850 and came to Baja California in the late 1860s. Ibarra was enterprising, and throughout his career he pursued a variety of businesses. He came to dominate mining in the southern part of Territorio Norte, especially around Campo Alemán, Calmalli, and El Arco. By the end of the century his mining interests had taken him into the northern part of the territory as well, where he was a major figure in the development of the Juárez placers near the U.S.

border in the late 1890s. He also controlled or had partial ownership in more than a dozen gold ventures in the Jacalitos and Zaragoza districts, inland from Ensenada.

Ibarra shared his success with many friends and relatives. His brothers Everado and Adelberto were partners in some of his mining schemes in Jacalitos and the Sierra de los Cucupás, and his brother-in-law, Dr. Isaac Rivas, was president of the Ibarra Mining Company which had offices in San Francisco. The following is one of the earliest biographical sketches of this regional mining magnate.

From the *Lower Californian*, November 1, 1895

One of the busiest men on the Peninsula these days is Emiliano Ibarra, and the saying that he allows no grass to grow under his feet is putting it mild. No sooner than he sold his interest in the Ibarra Mining company at Calmalli, than he started in mining afresh, and he interested himself in various other enterprises in different parts of the country.

Don Emiliano recently bonded the Recompensa in the Jacalitos district . . . In the Pineries, Expectacion Carillo has charge of the cattle that were recently bought by Ibarra . . . But Don Emiliano is essentially a miner . . .

A short sketch of Don Emiliano's life might be of interest to our readers. He is a native of the district of the Rio Enerte in the State of Sinaloa. The Ibarra family were among the first to come into Sinaloa — being of the old Spanish *conquistadores*, and an Ibarra was one of the first men to undertake mining in that State.

Don Emiliano left his native State when a young man and came to the Peninsula. He was in business for awhile at La Paz and then for a time was in the orchilla business, managing native labor on the desert, where he had to depend entirely on his own resources and courage to keep order among an unruly lot of men.

When the excitement broke out over the gold placers at Calmalli in 1883, he went there. No water was to be had and he sunk a well and made a little money in that manner. He then got hold of all the quartz mines that he could. Calmalli at that time was an absolute desert, and the only way to obtain supplies was over a terrible mountain trail of eighty miles to the Gulf-side and by a casual schooner to Guaymas . . .

Ibarra, nothing daunted by difficulties which would have discouraged most men, and with hardly any money, started to develop his property. He soon had gathered all the Mexicans in that country about him — to whom his word is law — and a road was opened to the Pacific. By this means he was enabled to occasionally get supplies from San Diego by a schooner. Many times, however, through the delay of schooners they were reduced to venison, antelope, and turtle from the lagoon at Santo Domingo for subsistence. Roads were made later to the different mines, of which he had about fourteen, and a ten-

stamp mill was placed on one of the mines. After struggling eleven years to develop this property without capital, he finally succeeded in forming a company in San Francisco, and two years later disposed of his interest in the group of mines controlled by the company at a round sum.

Ibarra is a man with a big heart and could never refuse help to a friend, and had it been otherwise he would be many thousand dollars richer than he is now . . . The energy and enterprise which Don Emiliano possesses is the sort of stuff to develop the mineral and other resources of this Peninsula.

THE SEMIPRECIOUS STONE onyx, a variety of quartz, was very much in demand in the early 20th century and was quarried in Baja California for more than 60 years. There were several active quarries around the village of El Mármol, in the center of the peninsula. The deposits at El Mármol were notable both for the high quality of the stone and their yield of large blocks. The most long-lived of the quarries was the Southwest Onyx and Marble Company of San Diego. Mining began in the district just before the turn of the century and continued until 1958 when it could no longer compete with cheaper onyx from central Mexico.

The following accounts describe the uses of onyx:

Hoping to be able by next steamer to give you more ample news about the new placers which, if we have to believe the happy ones returned, leave the tales of the Arabian Nights eclipsed. — Feliciano Aldrete (from Lower Californian, October 24, 1889)

From the *Mexican Mining Journal*, October 1912

PEDRARA ONYX CO.

The onyx used in the new Spreckels theater of San Diego, which cost over \$1,000,000 and is considered to be one of the finest playhouses in the United States, came from the Pedrara Onyx company's quarries of this state [Baja California]. The entire lobby, including box office, elevator recess and stairways, are finished in Pedrara onyx on both walls and ceilings, making one of the largest contracts ever executed for onyx. Some of the largest single slabs of polished onyx ever cut may be seen on the face of the pilasters in the lobby of this theater.

Unidentified newspaper clipping from a collection in the San Diego Public Library, 1940

Dashing around from office to saw-room, from crusher to polishing room and across the huge sunny

yards of the Southwest Onyx and Marble Company, J.W. Fisher, president, explained that his was the only plant of its kind in Southern California.

Onyx is shipped from the El Marmol quarries in Baja California, 300 miles "south of the border."

Finished products are bought by Chicago and New York companies: Schaeffer, Parker, Waterman and New Diamond Pen companies. From the central plants, these finished pen sets and clocks are shipped or freighted back across the country to retailers.

Crosses, altar facings, and similar ecclesiastical objects are among the company's marble and onyx projects. In addition to these, they also make vases, jardinières, candlesticks, soda fountain balls, counter tops, columns, showcase bases, gear-shift knobs, ash trays, steering-wheel knobs, and interior trim for homes.

The onyx fountain-pen set you buy, the cross at church, the theater lobby you pass through have all seen the experienced workmanship of the San Diego Southwest Onyx and Marble Company.

THE MINING BOOM IN BAJA California did not last long. Lack of perseverance was not the problem — geological resources were. For the gold deposits at most of the important sites in northern Baja California were placers. Rich placers often lead to "boom" excitement: one can always hope to find another nearby placer deposit, or even better, the "mother lode" of hard rock from which these particles originated. The memory of the first gold-rich finds sustained several decades of prospecting in Baja California. To this day, however, no extensive mother lode has been found on the peninsula.

In spite of the lack of major discoveries, prospectors and miners did have a considerable impact on Baja California and in ways that had far greater staying power than their few months or years of exploration might suggest. Mining was the first important economic driving force in what was essentially an undeveloped land.

Prospectors pressed into any region that promised mineral wealth, no matter how inaccessible or inhospitable, and as a result provided knowledge of the land, flora, and fauna that would otherwise not have accumulated. Many of the region's roads and settlements originated as part of mining or milling projects. The city of Ensenada, for example, was founded as a regional mining center and port — a fact not realized by many Ensenadans, nor by many mining historians.

Enthusiasm was high and profits were low, but the mining and milling efforts exerted by the seekers of fortune changed life forever in the northern half of Baja California. ■

Acquisitions

LOST AND FOUND TRADITIONS

In 1977, Ralph T. Coe, a scholar of Native American art, began a series of visits to tribal groups across the U.S. and Canada. His purpose was to assemble an exhibition of contemporary American Indian art. In the process, the question emerged of whether, in the face of the profound cultural disruption to which Native Americans have been subjected, the distinctive features of traditional American Indian art had survived to manifest themselves in contemporary forms in a significant way.

His effort grew into an eight-year project in which Coe pushed far beyond his scholarly grounding into the deepest aspects of his subjects' daily life. Through the artisans with whom he collaborated, he found the answer to his question: Native American culture, particularly through its arts and crafts, is alive, vigorous, and unquestionably viable.

His project culminated in the acquisition of 507 outstanding pieces of Native American beadwork, silverwork, woodwork, basketry, and weaving, 383 of which became the exhibiton Lost and Found Traditions: Native American Art 1965-1985. The collection comprises works from 93 tribes from all areas of the U.S. and Canada: Northern and Southern Woodlands, Great Lakes, Prairie, Plains, Plateau, Southwest and Far West, Athapaska, and Northwest Coast. The exhibition was assembled for the American Federation of Arts, with crucial long-term support from American Can Company (now Primerica). It traveled to nine American museums between 1986 and 1989.

In 1991, the AFA began looking for a permanent home for the works, and of the twenty museums that qualified to receive the collection as a gift, the

Bobby Hansson



Kerfed box, 1982-85. Red cedar, paint, electronics, hair. Kerfing is a way of cutting or sawing transversely in order to permit bending. This box was made by carver Greg Colfax of the Makah Indian Reservation in Neah Bay, Washington.

BELOW

War shirt, 1982-83. Cloth, hide, old beads, thread, weasel strips, otter fur, brass beads. Made by Joyce Growing Thunder Fogarty, Assiniboine/Sioux.





Los Angeles County Museum of Natural History was selected.

In making its choice, the AFA noted that the Los Angeles area has the largest concentration of American Indians of any urban center in the country, and that the Natural History Museum has had a longstanding commitment to collecting Native American art. In recent years in particular, the museum has sought to acquire contemporary works that reflect the neo-traditional mix embodied in *Lost and Found Traditions*.

The collection is truly continental in scope, the only one of its kind in existence. One of its principal virtues is the way it was put together, with the collector visiting extensively the actual places and people concerned in his research. An informed collector and a world authority on Native American art, Coe brought to his task respect and a feeling for the tremendous diversity and originality of the traditions he believed still existed. In contrast to many collecting biases, in which items are selected with narrow constraints (by age, size, availability, picturesqueness, tribal affilia-

tion, aesthetic or functional values, and so on), each piece in *Lost and Found Traditions* was chosen from the point of view of its own aesthetic tradition.

The Natural History Museum welcomes the collection because the large Native American population in Los Angeles represents tribes from all over the country. With such a diverse assemblage of works, people may visit and bring their children to see some of the finest examples that exist of the works of their own and other heritages. The fact that the articles are recent — made only two decades or less ago — also sends the message to every visitor that Native American cultures did not die — a message especially important for museums to convey. Funds from the Hearst Endowment will enable the museum to add to the collection.

In the summer of 1992, the collection was turned over to the Natural History Museum. Selections from the collection will be on view in the museum's new Times Mirror Hall of Native American Cultures (see page 5).

The objects that museums acquire and preserve are in effect a permanent record of human endeavors and the natural world; at the heart of all of the Natural History Museum's activities are its collections. In Acquisitions, TERRA showcases a recent addition to the museum's holdings of more than 35 million specimens and artifacts.

ABOVE

Baby coverlet and pillow, 1981, Felt, beads, pillow stuffing. Made by Kim Brook, Malecite.

Pair of beaded sneakers, 1982. Made by Effie Tybrec, Sioux.



Southland Diorama

THE ORANGETHROAT PIKEBLENNY

Imagine living in a tunnel so small that space was sufficient only to squeeze in and out. Everyday life would be a challenge, general housekeeping chaotic. Although shelter would be adequate, daily tasks could take the skills of a gymnast. And what about soliciting a mate, consummating the act, and raising young?

It seems impossible, yet the orangethroat pikeblenny, *Chaenopsis alepidota*, accomplishes it. Pikeblennies live off the coast of southern California and Mexico in the abandoned tubes of the polychaete worm *Chaetopterus*. They seek out the tubes in sandy areas and prefer ones that are flush with the bottom, although tubes that protrude from sand are occasionally selected. Life for the elongated scaleless pikeblenny lasts at least six years, and it reaches about 18 centimeters (seven inches) in length. In California waters they are considered a rare fish, but there may be more of them than is suspected, since they can easily escape detection by withdrawing into their tubes.

Pikeblennies are territorial, and where many worm tubes exist, they can be quite dense, separated by distances of one meter. From the safety of their tubes, these large-mouthed predators rush out to attack small fish and other prey, including other pikeblennies. Occasionally they leave their tubes and swim freely over the bottom, usually in areas of rocky-cobble that have interstitial spaces that may provide a means to escape predators. How they clean their tubes is unclear, and it may be that they simply relocate when a tube becomes too squalid.

During courtship, the male attracts females with an elaborate dance that features his long, black-spotted dorsal fin

and is accomplished while he remains partially inside his tube. As the dance proceeds, a female will become excited enough to dash forward and encircle the male's tube, vibrating her body and fins wildly. Her vibrations are so intense that sediment around the tube is displaced and a circular depression forms in the sand around the male's tube. A particularly attractive and active male may have a deep depression about his tube.

Spawning occurs outside the tube, as the eggs are fertilized and broadcast into the water column. The spent female returns to her tube, whereas dance fever once again overtakes the male and his acrobatics begin anew.

Eggs hatch and larvae develop in the water column at the mercy of the currents. As larvae metamorphose, they descend to the bottom and immediately search for an appropriately sized empty worm tube. They quickly take up residence, slithering inside tail first. By the end of the first year, they will have grown to about six centimeters (2.5 inches), and will grow at the rate of 2.5 centimeters (an inch) a year.

Orangethroat pikeblennies are widely but disjunctively dis-

tributed in the waters off southern California, and continue to survive precariously. They are known only from King Harbor on the mainland, but are found on three of the Channel Islands — Anacapa, Santa Catalina, and San Clemente. During the 1960s, a large population existed on the west end of Santa Catalina Island along the lee side, near Chalk Cliffs in Big Fisherman's Cove. However, winter storms destroyed the *Chaetopterus* worm tubes, and subsequent cold waters killed the pikeblennies. Storms in January of 1988, and cold water conditions later during that year, decimated the population established at King Harbor.

ROBERT J. LAVENBERG
Curator and Section Head,
Ichthyology

Southland Diorama is a TERRA column that highlights the incredible diversity of animal and plant life still to be found in southern California. Each issue features an example of one of the many species — extant and extinct, native and introduced, abundant and endangered — that are found in astonishing variety in one of the world's largest urban centers.

Orangethroat pikeblenny at Little Flower Reef, San Clemente Island. This animal was photographed in 1991 at a depth of about nine meters (30 feet). Photograph by Dick Turner.



Dick Turner

Focus on the West

THE SAN LUIS REY MISSION

SAN LUIS REY WAS THE EIGHTEENTH in a chain of 21 missions established by the Franciscans in California. On June 13, 1798, Fray Fermin de Lasuén dedicated the site, which was located in the Santa Margarita Valley midway between the San Diego and San Juan Capistrano missions. Father Antonio Peyri, the senior priest assigned to the mission, built the first adobe church in 1802 and between 1811 and 1815 oversaw construction of what was to be the largest mission in California.

The Spanish government intended the missions to be temporary institutions that would help convert the local inhabitants to Christianity and train them to be productive and loyal subjects of Spain. To this end, the Crown granted the missions great landholdings. The neophytes, or Indian converts, tilled the fields and learned animal husbandry and the secrets of the manual arts. Once they had joined the missions, however, the converts were not permitted to leave and were thus bound to a form of involuntary servitude.

Under Spanish law, the missions were supposed to be temporary. The Crown expected them to support themselves after a period and become civil settlements like other towns in America. The lands would be distributed to the resident Indians.

But the Church, for a number of reasons, never voluntarily phased out the mission system. Instead, the new Mexican government, after independence, moved to bring it to an end; in 1833 California governor José Figueroa issued a sweeping secularization decree that converted the missions into parish churches. The Indians were emancipated, and the Franciscans were allowed to remain as parish priests. But the mission lands were confiscated and sold to non-Indians.

After secularization, the fortunes of San Luis Rey mission rapidly declined. In 1846 the mis-

sion buildings were sold to private individuals, and remained in private hands over the next 20 years. For a time the mission was even occupied by the United States army.

Eventually, the U.S. courts declared the sale of the mission to have been illegal and, in March 1865, President Abraham Lincoln ordered the San Luis Rey mission buildings returned to the Church. By this time they had fallen into disrepair, and looters had stripped the buildings of everything of value, including doors, bells, roof tiles, and rafters; even some of the arches were blown down for bricks.

The mission stood empty and abandoned for almost another 30 years, functioning chiefly as an out-of-the-way attraction for tourists eager to see a "real" American ruin.

In 1892 Father Joseph O'Keefe was assigned to rehabilitate the crumbling structure and establish a seminary for the training of Mexican Franciscan priests. Father O'Keefe, known to history as the "rebuilder," remained at San Luis Rey until his retirement in 1912, presiding over the reconstruction of one of California's great historical landmarks. In this photograph, taken around the turn of the century, Father O'Keefe stands in the ruins of San Luis Rey's mortuary chapel, pondering the immensity of the task before him.

ERROL STEVENS
*Curator, Section Head
Seaver Center*

Focus on the West is a TERRA feature that presents the photographic highlights of the museum's Seaver Center for Western History Research. The Seaver Center is rich in photographs and other materials relating to the history of the American West.



GREENE COLLECTION, 75-126

Exposition

Q: If the Pleistocene animals from the La Brea tar pits lived during the "Ice Ages," why are many of the Pleistocene sea shells I find in the San Pedro area tropical species?

A: According to Dr. George L. Kennedy, museum paleontologist and Quaternary geologist, our reader has hit upon one of the most striking aspects of Pleistocene climate: its extreme variability. Most readers probably associate the Pleistocene Epoch, one of two that make up the Quaternary Period, with continental ice sheets, woolly mammoths, and peopling of the New World. Although it is true that climatic conditions were generally cooler throughout much of the Pleistocene, they were not continuously so.

Our understanding of the mechanisms that drive Quaternary paleoclimatic change has undergone revolutionary advances in the last two decades. Global climatic regimes on a geologic scale relate ultimately to the amount and distribution of solar radiation (insolation) that reaches the earth. The extent of insolation is dramatically

affected by perturbations in the earth/sun orbital geometry, such as the eccentricity of the earth's orbit, the obliquity (tilt) of the earth's axis, and precession of the equinoxes. These "orbital forcing" parameters have periodicities of about 100,000 years, 41,000 years, and 23,000 years, respectively. Just as intersecting sets of ripples on a pond tend to cancel out or reinforce each other, so too do these orbital parameters similarly affect global climate on a geologic scale.

From the initiation of moderate-sized ice sheets about 2.5 million years ago to about 0.7 million years ago, paleoclimatic regimes were dominated by the effects of the 41,000-year rhythm of orbital obliquity. For most of the last million years, however, paleoclimatic cycles have been increasingly dominated by the 100,000-year rhythm of eccentricity, upon which were superimposed the effects of the 41,000-year obliquity and 23,000-year precessional cycles. As a result, the earth has been experiencing predominantly glacial conditions interrupted every 100,000 years or so by relatively short interglacial periods. Today, we live in the latest of these

warm interglacial periods, which has been termed the Holocene Epoch.

Returning to our reader's question, the different paleoclimatic conditions suggested by the Ice Age mammals from Rancho La Brea and the tropical mollusks from San Pedro are due to differences in their geologic age. It is important to note that, although the fauna and flora of Rancho La Brea lived between 11,000 and 40,000 years ago (during the last "Ice Age") and certainly indicate cooler conditions than exist in southern California today, they are not representative of the types of animals and plants that lived along the margins of the continental ice sheets. They are "Ice Age" only in the timing of their existence. On the other hand, the tropical fossil mollusks from San Pedro are from the Palos Verdes Sand, a marine formation that was deposited approximately 125,000 years ago, during one of the warmest interglacial periods in all of the Pleistocene. The presence in the Los Angeles Basin of these tropical mollusks, such as the species of *Chione* shown below, is irrefutable evidence that climates warmer than those of today existed in the geologic past.

Chione (Chionopsis) gnidia, a tropical eastern Pacific bivalve mollusk that ranges today from Cedros Island, on the outer coast of central Baja California, to Peru; 125,000 years ago, during the peak of the last interglacial period, it lived in warm water estuaries as far north as the Los Angeles Basin.



The museum's staff members are often asked to answer historical questions, or to identify artifacts and specimens that people have found, purchased, or inherited. Exposition is a TERRA feature in which the museum's staff will discuss interesting questions asked them by members and the general public.

Your View to the World

Costa Rica Natural History

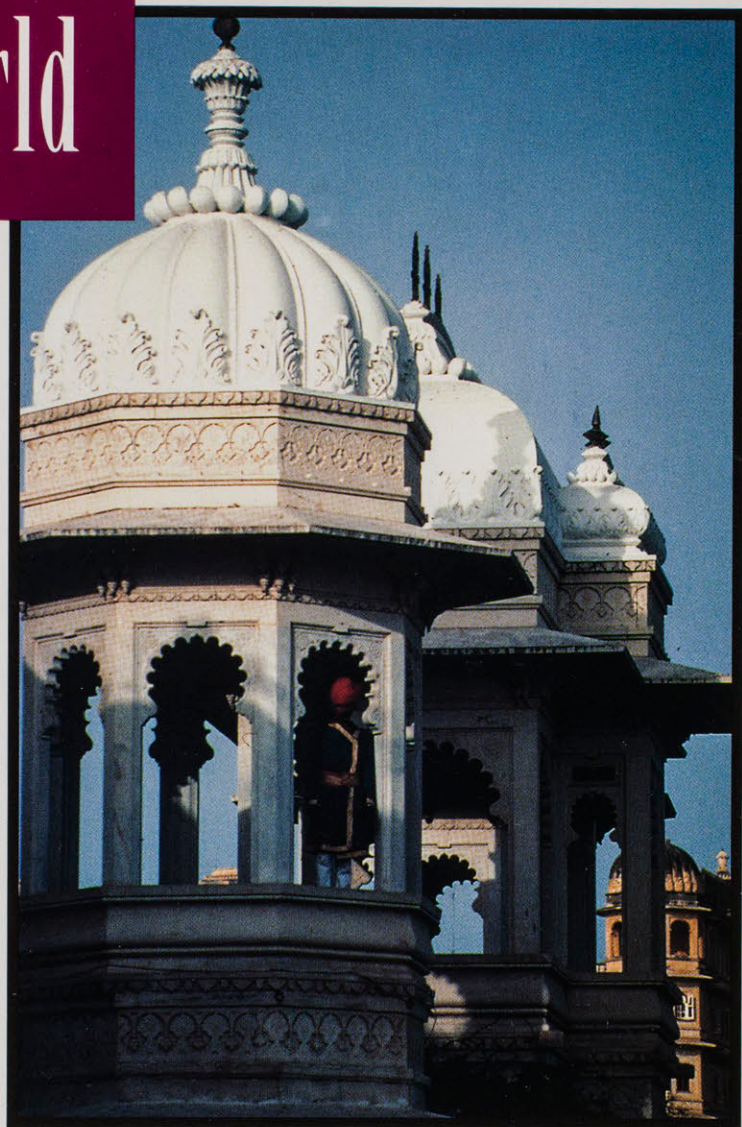
AUGUST 13 - 25, 1993

Explore this naturalist's paradise with Robert Gustafson, the Natural History Museum's Collections Manager in botany. Delight in Costa Rica's tropical rainforests, cool cloud forests, and tropical alpine regions. You may see an incredible abundance of wildlife, including the resplendent quetzal, scarlet macaw, howler monkey, three-toed sloth, green sea turtle, poison-dart frog, and coatimundi. Our itinerary includes the Monteverde Cloud Forest Reserve, Lomas de Barbudal Reserve, Las Espuelas, Santa Rosa National Park, Tilajari, Cano Negro National Wildlife Refuge, Tortuguero National Park, Cerro de la Muerte, and El Tapir. **\$2,700 including air fare.**

Turkey: Cradle of Civilization

SEPTEMBER 18 - OCT. 6, 1993

Exotic and thrilling, Turkey offers a wonderful blend of Roman ruins, glimpses into the Ottoman, Hittite, and Byzantine eras, and traditional arts and crafts. Visit Cappadocia, an area of unique geologic features and fascinating early Christian history. Continue to Konya and Pamukkale, the famous "Niagara in Stone," where steaming water cascades into a series of pools, crystallizing into stalactites and fans. Experience Antalya, Bodrum, and Ephesus. Sail along the Gokova Coast in "gulet" yachts before concluding your tour in Istanbul, the intriguing city where east and west blend. **\$3,395 plus air fare.**



TREASURES OF INDIA
PHOTOS: ERIC HOVANITZ



Natural Treasures of India

OCTOBER 22 - NOVEMBER 15, 1993

Join us on a natural history tour of India, featuring its internationally recognized wildlife preserves. Study leader Julian Donahue, Assistant Curator of Entomology at the Natural History Museum, lived for three years in India, studying the rich bird and butterfly fauna of the subcontinent. Take in India's wealth of temples, palaces, and monuments, the legacy of five thousand years of civilization, and admire her varied and beautiful people. Experience the splendor of the Dussera Festival in Mysore and Dawali Day in Jaipur. At Nagarhole and Kanha National Parks, we may see barking deer, leopards, and wild elephants, and at Ranthambhor, tigers! Visits to Keoladeo and Periyar will allow us to identify many of India's 200 species of birds. **\$5,475 plus air fare.**

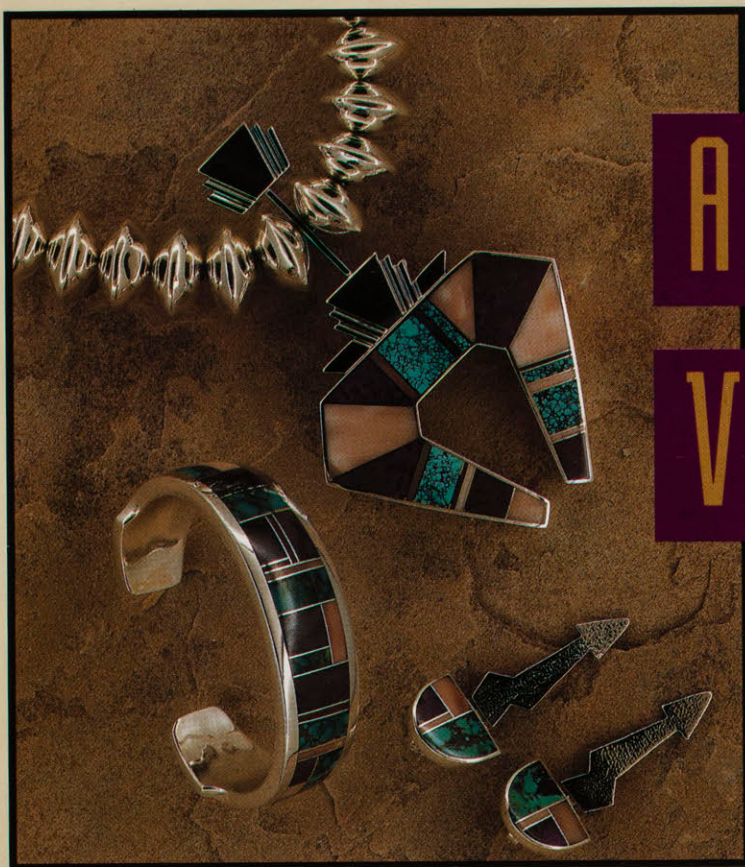
NATURAL HISTORY MUSEUM

For further information, please contact
Karen Hovanitz, Natural History Museum
Travel Program, (213) 744-3350

Travel Program 1993



Ruth Mecklenburg
Library



A UNIQUE VISION

Jewelry designed by Ray Tracey

Ray Tracey is an award-winning Navajo artist who is well-known for his distinctive jewelry. Ray designs each piece and is assisted in the execution of those designs by Native American artisans at his studio in Gallup, New Mexico. ■ Only the finest gemstones from mines around the world are utilized. In the pieces pictured above, the rich tones of sugilite, pink coral, and Chinese turquoise are combined with brightly polished silver to create a stunning bracelet, dramatic naja necklace, and earrings representing rain clouds and lightning.

■ Ray Tracey's jewelry designs are an important example of the innovative new directions of traditional Navajo stone and silverwork and are part of the continuing evolution of Native American art forms. Ray Tracey's work has been collected by the museum for permanent display in the TIMES MIRROR HALL OF NATIVE AMERICAN CULTURES.

Visit the museum's Ethnic Arts Shop to select from a varied collection of Ray Tracey's jewelry and to purchase work by other prominent contemporary Native American artists.

ETHNIC ARTS SHOP

Natural History Museum
900 Exposition Blvd.
Los Angeles, CA 90007
213/744-3488

